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Koyanagi et al.

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(45) Date of Patent: May 24, 2016

(54) RESOURCE ALLOCATION METHOD, IDENTIFICATION METHOD, RADIO COMMUNICATION SYSTEM, BASE STATION, MOBILE STATION, AND PROGRAM

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(73) Assignee: **NEC CORPORATION**, Tokyo (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 404 days.

(21) Appl. No.: **13/000,301**

(22) PCT Filed: **Jun. 19, 2009**

(86) PCT No.: **PCT/JP2009/061194**

§ 371 (c)(1),
(2), (4) Date: **Dec. 20, 2010**

(87) PCT Pub. No.: **WO2009/154270**

PCT Pub. Date: **Dec. 23, 2009**

(65) **Prior Publication Data**

US 2011/0110322 A1 May 12, 2011

(30) **Foreign Application Priority Data**

Jun. 20, 2008 (JP) 2008-161752

(51) **Int. Cl.**
H04W 72/04 (2009.01)
H04L 1/00 (2006.01)
H04L 5/00 (2006.01)

(52) **U.S. Cl.**
CPC ***H04L 1/0029*** (2013.01); ***H04L 5/006*** (2013.01); ***H04L 5/0041*** (2013.01); ***H04L 5/0064*** (2013.01); ***H04L 5/0092*** (2013.01); ***H04L 5/0094*** (2013.01)

(58) **Field of Classification Search**
CPC H04L 1/00; H04L 1/0003; H04L 1/0009; H04L 1/0025; H04L 1/0029; H04L 1/0041
USPC 370/310–350
See application file for complete search history.

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Primary Examiner — Jamal Javaid
(74) *Attorney, Agent, or Firm* — Sughrue Mion, PLLC

(57) **ABSTRACT**

To solve a problem that although the increase of the number of frequency blocks by allocating discontinuous subcarriers (RBs) as in OFDM enables an increase in multi-diversity effect and an improvement in throughput, the number of RB allocation patterns increases with the increase of the number of frequency blocks, resulting in an increase in the amount of information relating to the allocated RBs, the resource block allocation unit is determined when resource blocks discontinuous on the frequency axis are allocated to a terminal, and the number of bits of scheduling information indicating the allocated resource blocks by using Tree Based is set to the number of bits corresponding to the determined allocation unit.

4 Claims, 19 Drawing Sheets

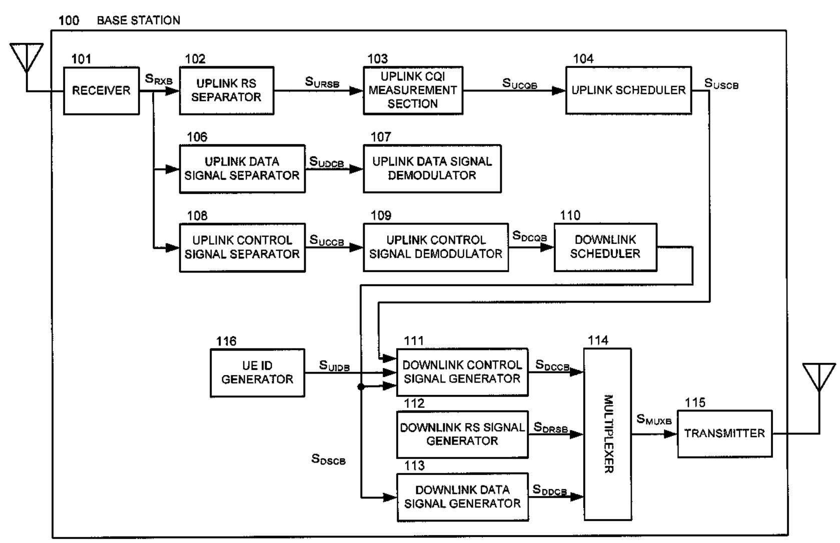

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FIG. 1

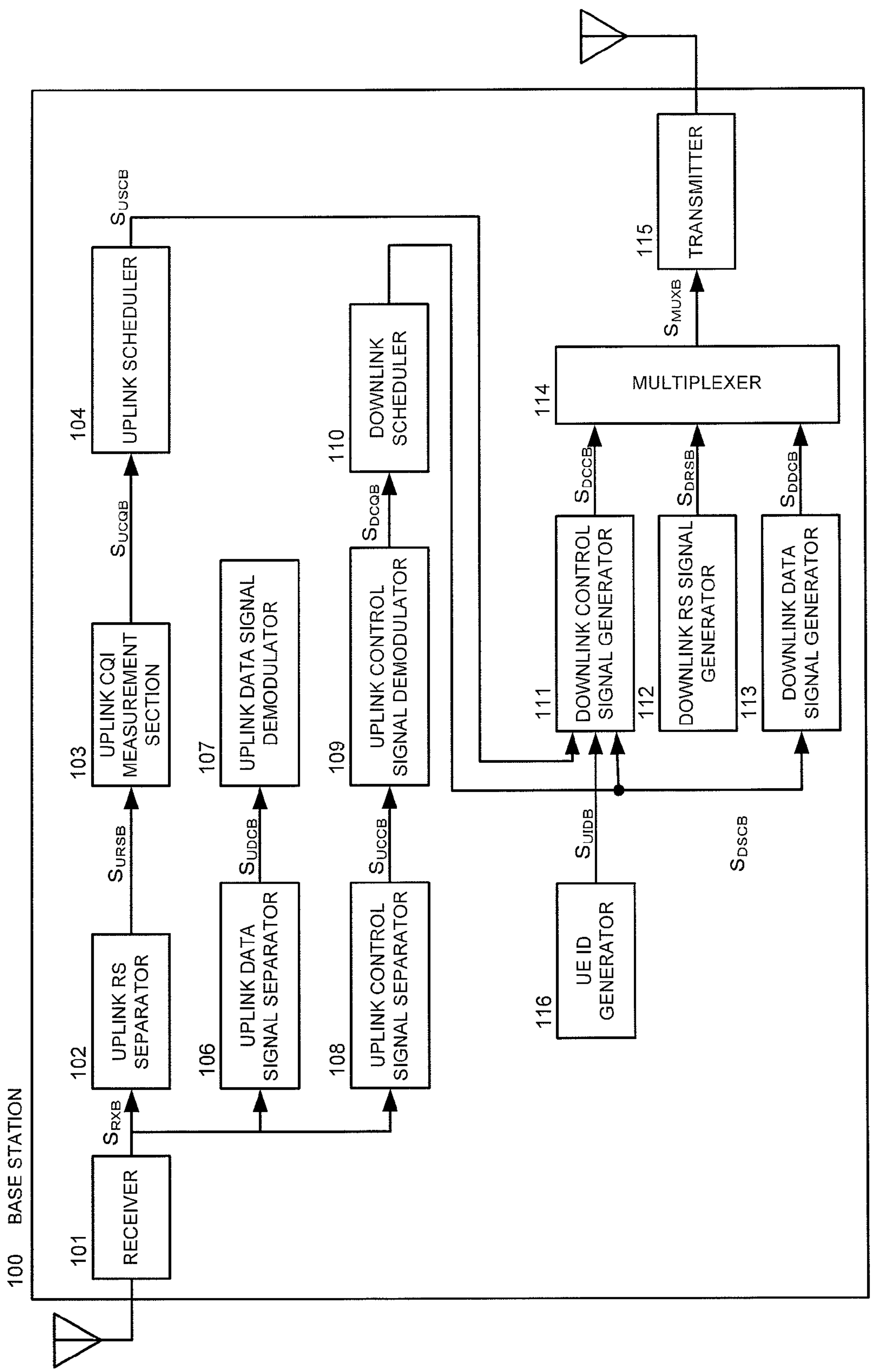

100 BASE STATION
101 RECEIVER
S_{RXB}
102 UPLINK RS SEPARATOR
S_{URSB}
103 UPLINK CQI MEASUREMENT SECTION
S_{UCQB}
104 UPLINK SCHEDULER
S_{USCB}
106 UPLINK DATA SIGNAL SEPARATOR
S_{UDCB}
107 UPLINK DATA SIGNAL DEMODULATOR
108 UPLINK CONTROL SIGNAL SEPARATOR
S_{UCCB}
109 UPLINK CONTROL SIGNAL DEMODULATOR
S_{DCQB}
110 DOWNLINK SCHEDULER
111 DOWNLINK CONTROL SIGNAL GENERATOR
S_{DCCB}
112 DOWNLINK RS SIGNAL GENERATOR
S_{DRSB}
113 DOWNLINK DATA SIGNAL GENERATOR
S_{DDCB}
114 MULTIPLEXER
S_{MUXB}
115 TRANSMITTER
116 UE ID GENERATOR
S_{UIDB}
S_{DSCB}

FIG. 2

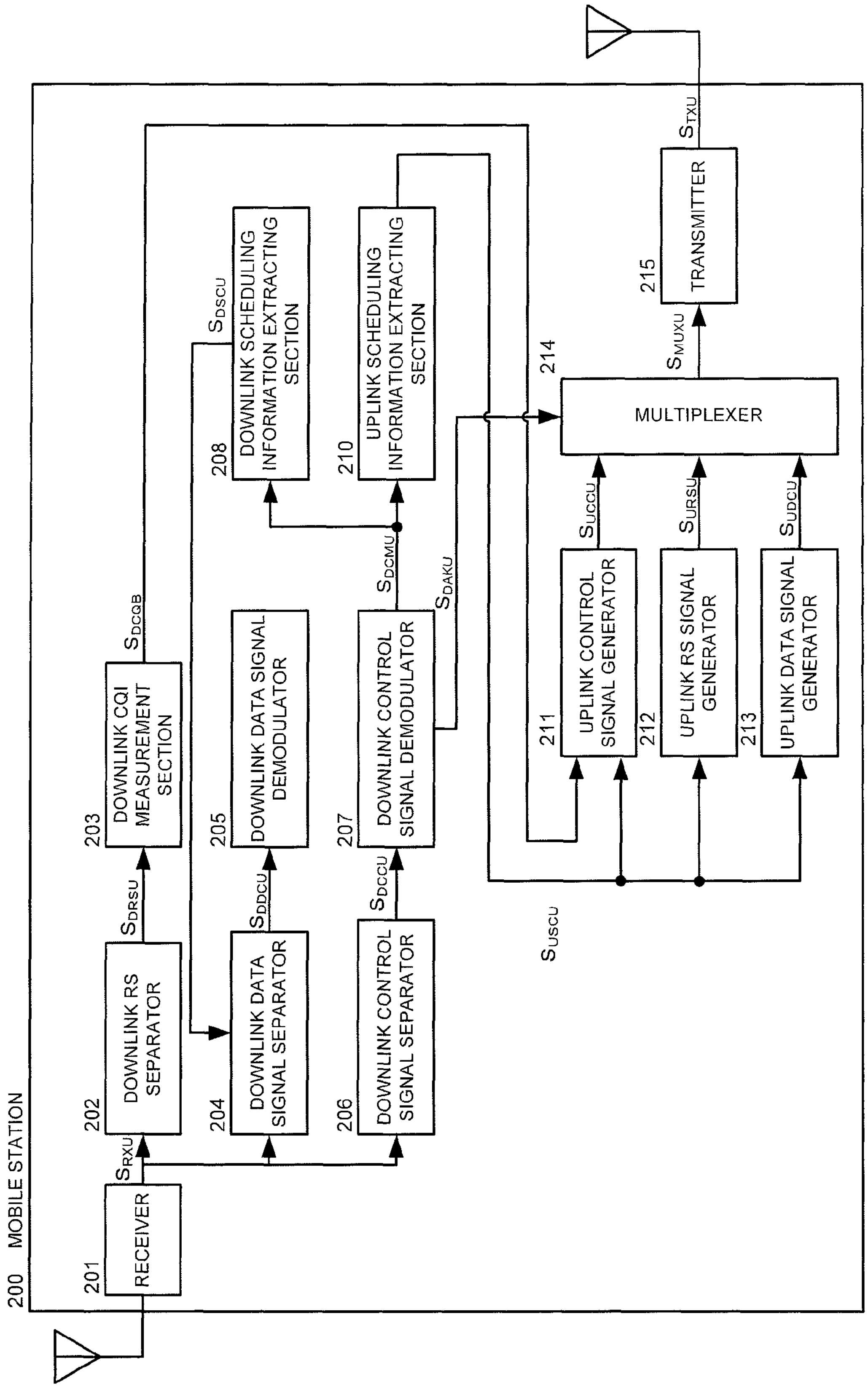

200 MOBILE STATION
201 RECEIVER
202 DOWNLINK RS SEPARATOR
203 DOWNLINK CQI MEASUREMENT SECTION
204 DOWNLINK DATA SIGNAL SEPARATOR
205 DOWNLINK DATA SIGNAL DEMODULATOR
206 DOWNLINK CONTROL SIGNAL SEPARATOR
207 DOWNLINK CONTROL SIGNAL DEMODULATOR
208 DOWNLINK SCHEDULING INFORMATION EXTRACTING SECTION
210 UPLINK SCHEDULING INFORMATION EXTRACTING SECTION
211 UPLINK CONTROL SIGNAL GENERATOR
212 UPLINK RS SIGNAL GENERATOR
213 UPLINK DATA SIGNAL GENERATOR
214 MULTIPLEXER
215 TRANSMITTER
S_{RXU}
S_{DRSU}
S_{DDCU}
S_{DCCU}
S_{DCQB}
S_{DSCU}
S_{DCMU}
S_{DAKU}
S_{USCU}
S_{UCCU}
S_{URSU}
S_{UDCU}
S_{MUXU}
S_{TXU}

FIG. 3

FREQUENCY BLOCK	1	2	3
ALLOCATION RESOLUTION	1RB	1RB	2RBS

FIG. 4

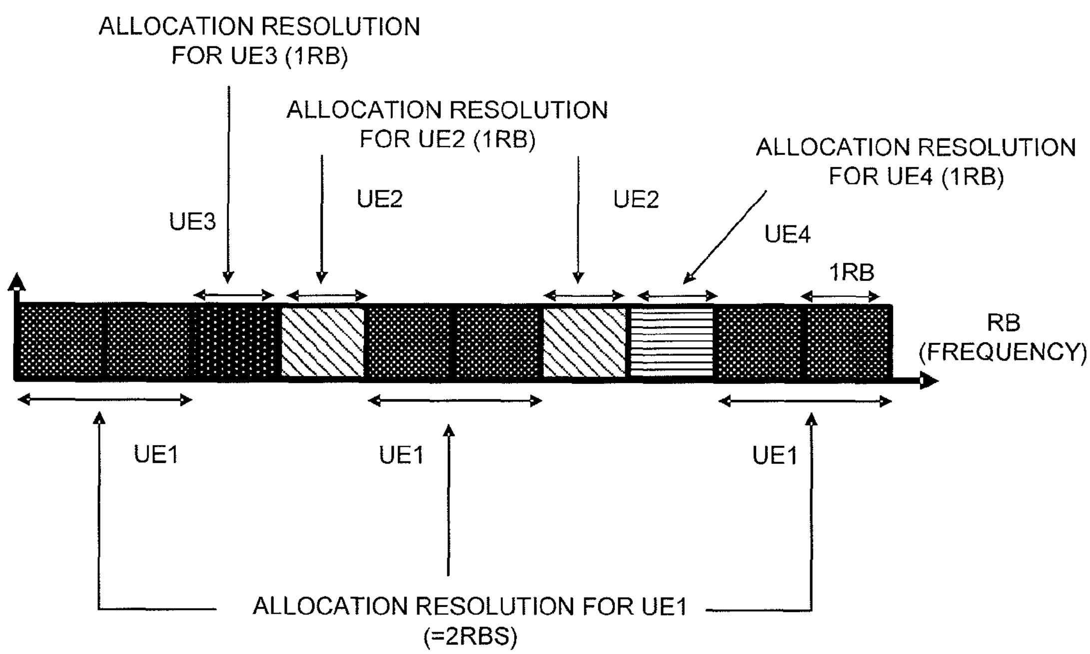
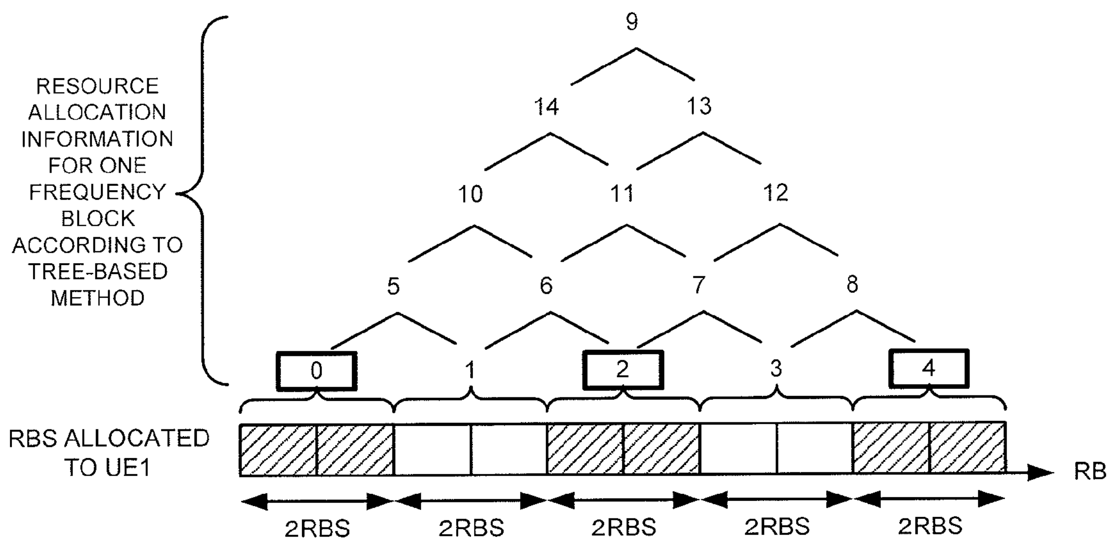
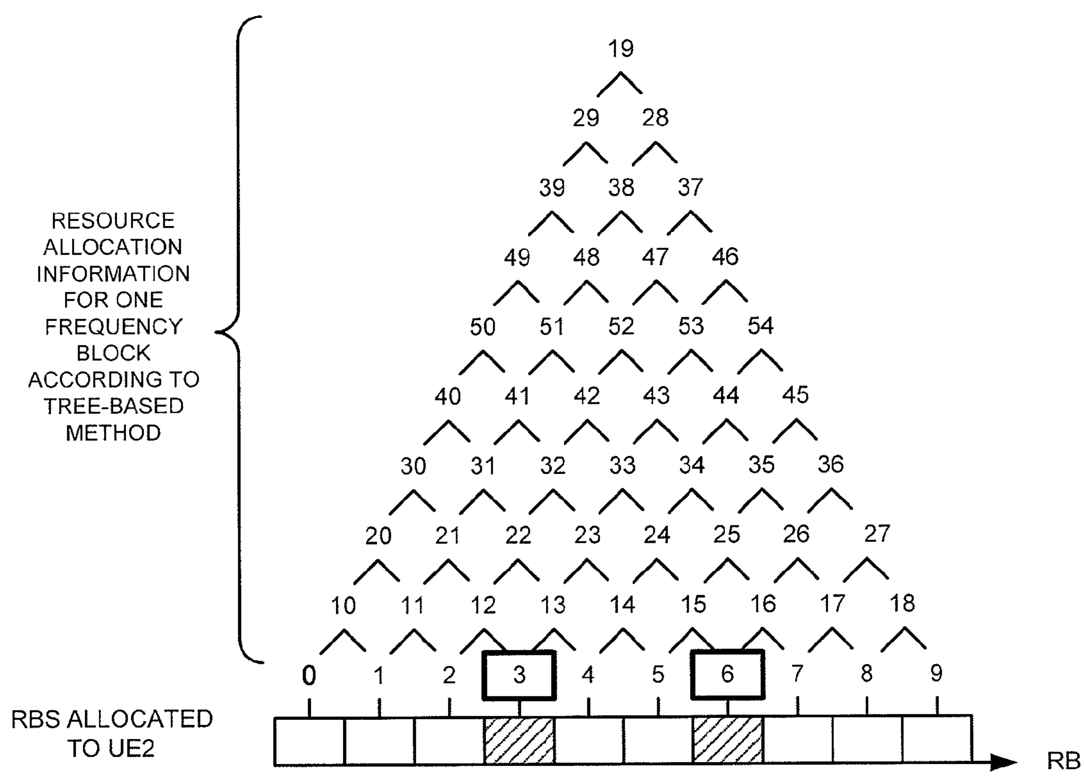


FIG. 5



9
14
13
10
11
12
5
6
7
8
0
1
2
3
4
RESOURCE ALLOCATION INFORMATION FOR ONE FREQUENCY BLOCK ACCORDING TO TREE-BASED METHOD
RBS ALLOCATED TO UE1
RB
2RBS
2RBS
2RBS
2RBS
2RBS

FIG. 6



19
29 28
39 38 37
49 48 47 46
50 51 52 53 54
40 41 42 43 44 45
30 31 32 33 34 35 36
20 21 22 23 24 25 26 27
10 11 12 13 14 15 16 17 18
0 1 2 3 4 5 6 7 8 9
RESOURCE ALLOCATION INFORMATION FOR ONE FREQUENCY BLOCK ACCORDING TO TREE-BASED METHOD
RBS ALLOCATED TO UE2
RB

FIG. 7

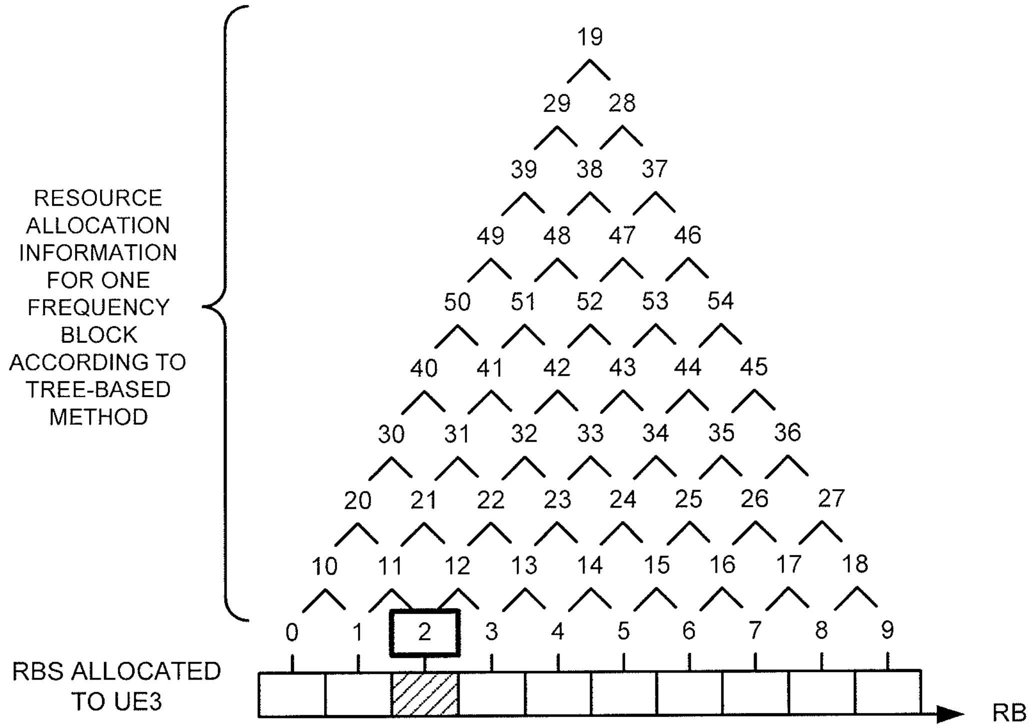

RESOURCE ALLOCATION INFORMATION FOR ONE FREQUENCY BLOCK ACCORDING TO TREE-BASED METHOD
19
29 28
39 38 37
49 48 47 46
50 51 52 53 54
40 41 42 43 44 45
30 31 32 33 34 35 36
20 21 22 23 24 25 26 27
10 11 12 13 14 15 16 17 18
0 1 2 3 4 5 6 7 8 9
RBS ALLOCATED TO UE3
RB

FIG. 8

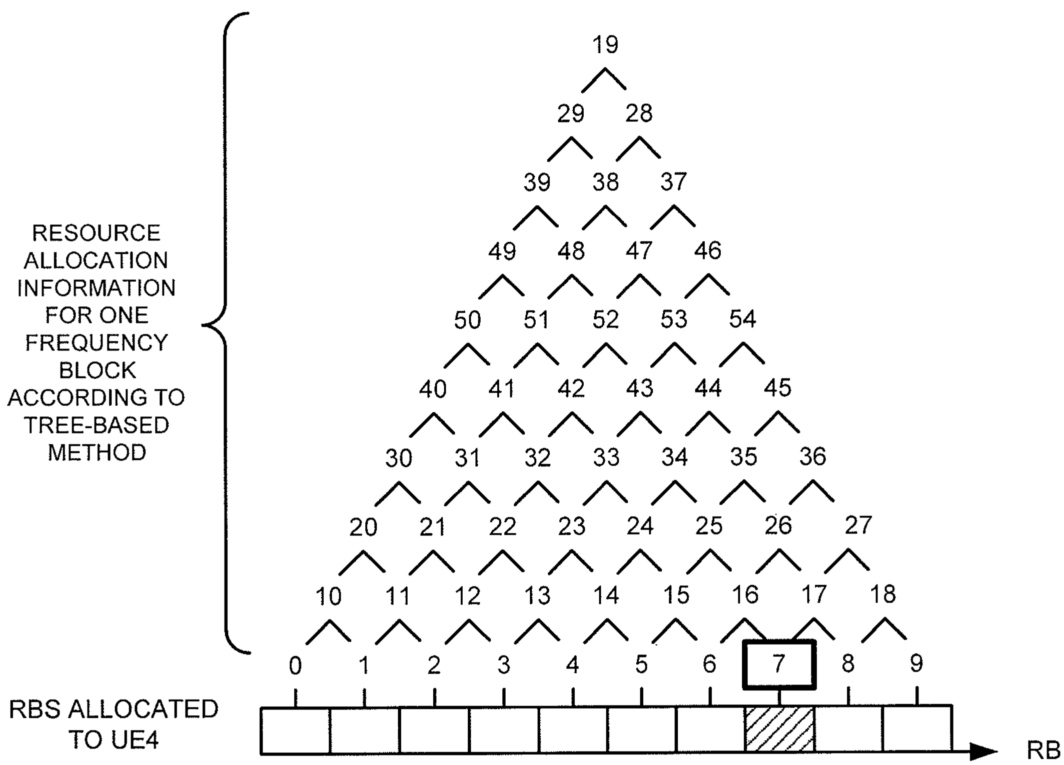
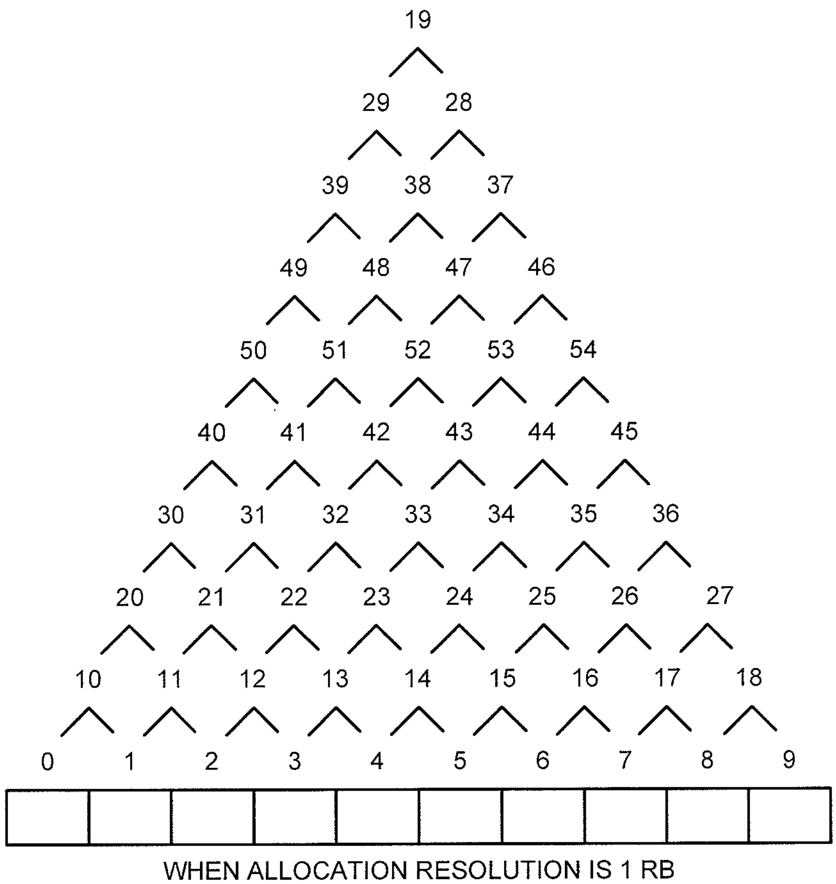

RESOURCE ALLOCATION INFORMATION FOR ONE FREQUENCY BLOCK ACCORDING TO TREE-BASED METHOD
19
29 28
39 38 37
49 48 47 46
50 51 52 53 54
40 41 42 43 44 45
30 31 32 33 34 35 36
20 21 22 23 24 25 26 27
10 11 12 13 14 15 16 17 18
0 1 2 3 4 5 6 7 8 9
RBS ALLOCATED TO UE4
RB

FIG. 9


19
29 28
39 38 37
49 48 47 46
50 51 52 53 54
40 41 42 43 44 45
30 31 32 33 34 35 36
20 21 22 23 24 25 26 27
10 11 12 13 14 15 16 17 18
0 1 2 3 4 5 6 7 8 9
WHEN ALLOCATION RESOLUTION IS 1 RB

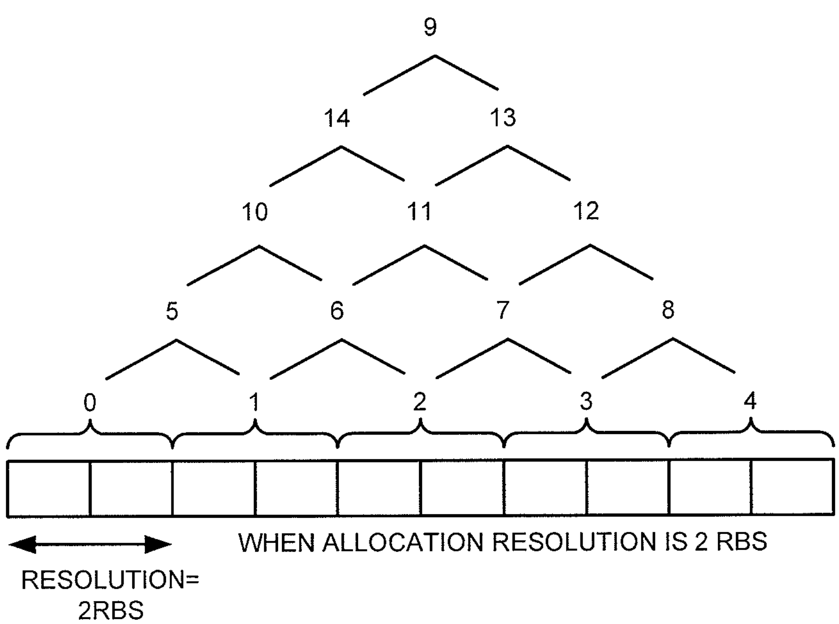

9
14 13
10 11 12
5 6 7 8
0 1 2 3 4
WHEN ALLOCATION RESOLUTION IS 2 RBS
RESOLUTION=
2RBS

FIG. 10

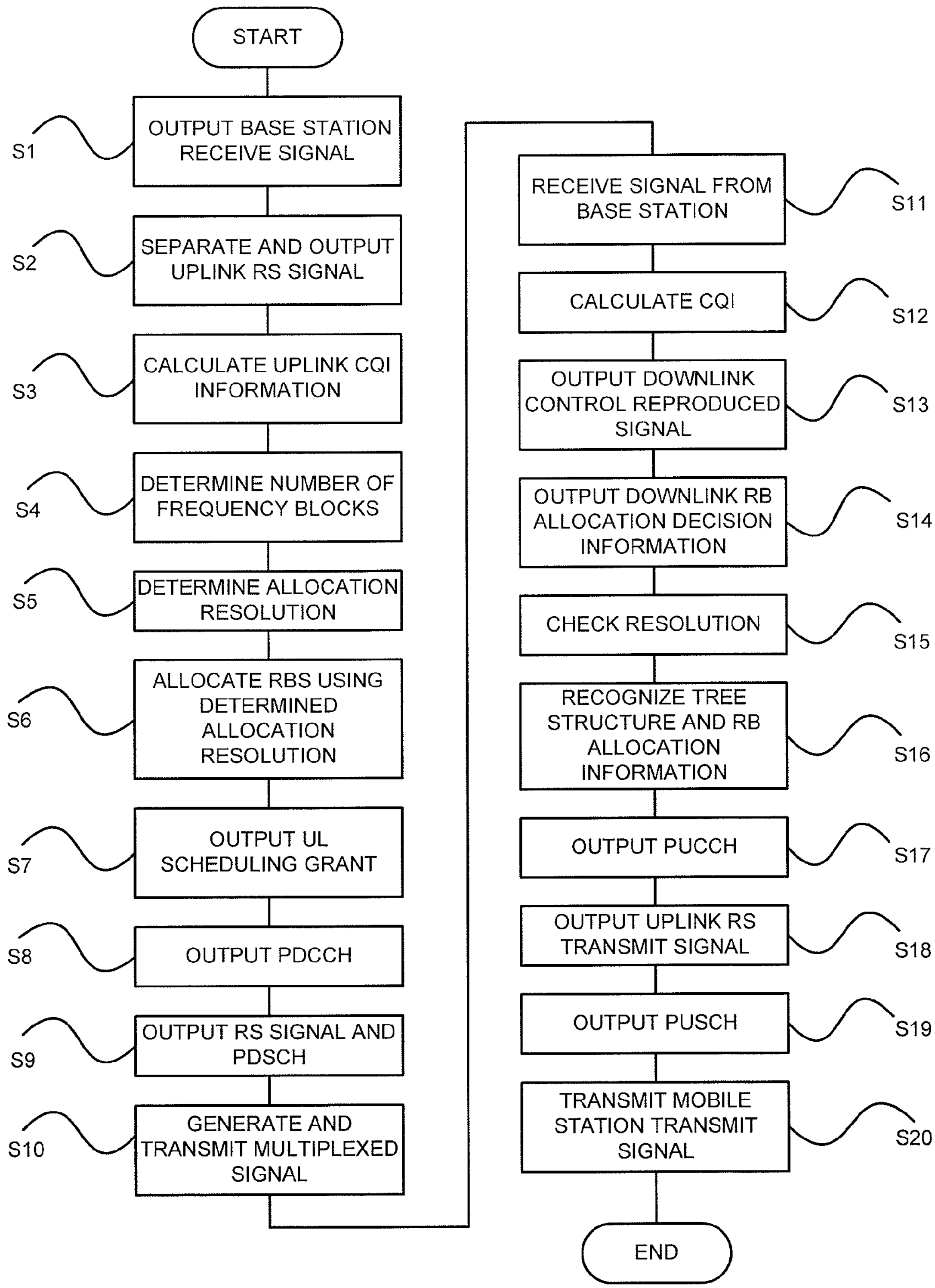

START
OUTPUT BASE STATION RECEIVE SIGNAL
S1
SEPARATE AND OUTPUT UPLINK RS SIGNAL
S2
CALCULATE UPLINK CQI INFORMATION
S3
DETERMINE NUMBER OF FREQUENCY BLOCKS
S4
DETERMINE ALLOCATION RESOLUTION
S5
ALLOCATE RBS USING DETERMINED ALLOCATION RESOLUTION
S6
OUTPUT UL SCHEDULING GRANT
S7
OUTPUT PDCCH
S8
OUTPUT RS SIGNAL AND PDSCH
S9
GENERATE AND TRANSMIT MULTIPLEXED SIGNAL
S10
RECEIVE SIGNAL FROM BASE STATION
S11
CALCULATE CQI
S12
OUTPUT DOWNLINK CONTROL REPRODUCED SIGNAL
S13
OUTPUT DOWNLINK RB ALLOCATION DECISION INFORMATION
S14
CHECK RESOLUTION
S15
RECOGNIZE TREE STRUCTURE AND RB ALLOCATION INFORMATION
S16
OUTPUT PUCCH
S17
OUTPUT UPLINK RS TRANSMIT SIGNAL
S18
OUTPUT PUSCH
S19
TRANSMIT MOBILE STATION TRANSMIT SIGNAL
S20
END

FIG. 11

DF (FREQUENCY BLOCK)	1	2	3	4
ALLOCATION RESOLUTION	1RB	1RB	2RBS	5RBS
NUMBER OF BITS OF INFORMATION REQUIRED FOR NOTIFICATION PER FREQUENCY BLOCK ACCORDING TO TREE-BASED METHOD	13	13	11	8
NUMBER OF BITS OF INFORMATION REQUIRED FOR NOTIFICATION OF MAXIMUM OF DF FREQUENCY BLOCKS ACCORDING TO TREE-BASED METHOD	15(=13x1+2)	28(=13x2+2)	35(11x3+2)	34(8x4+2)

FIG. 12

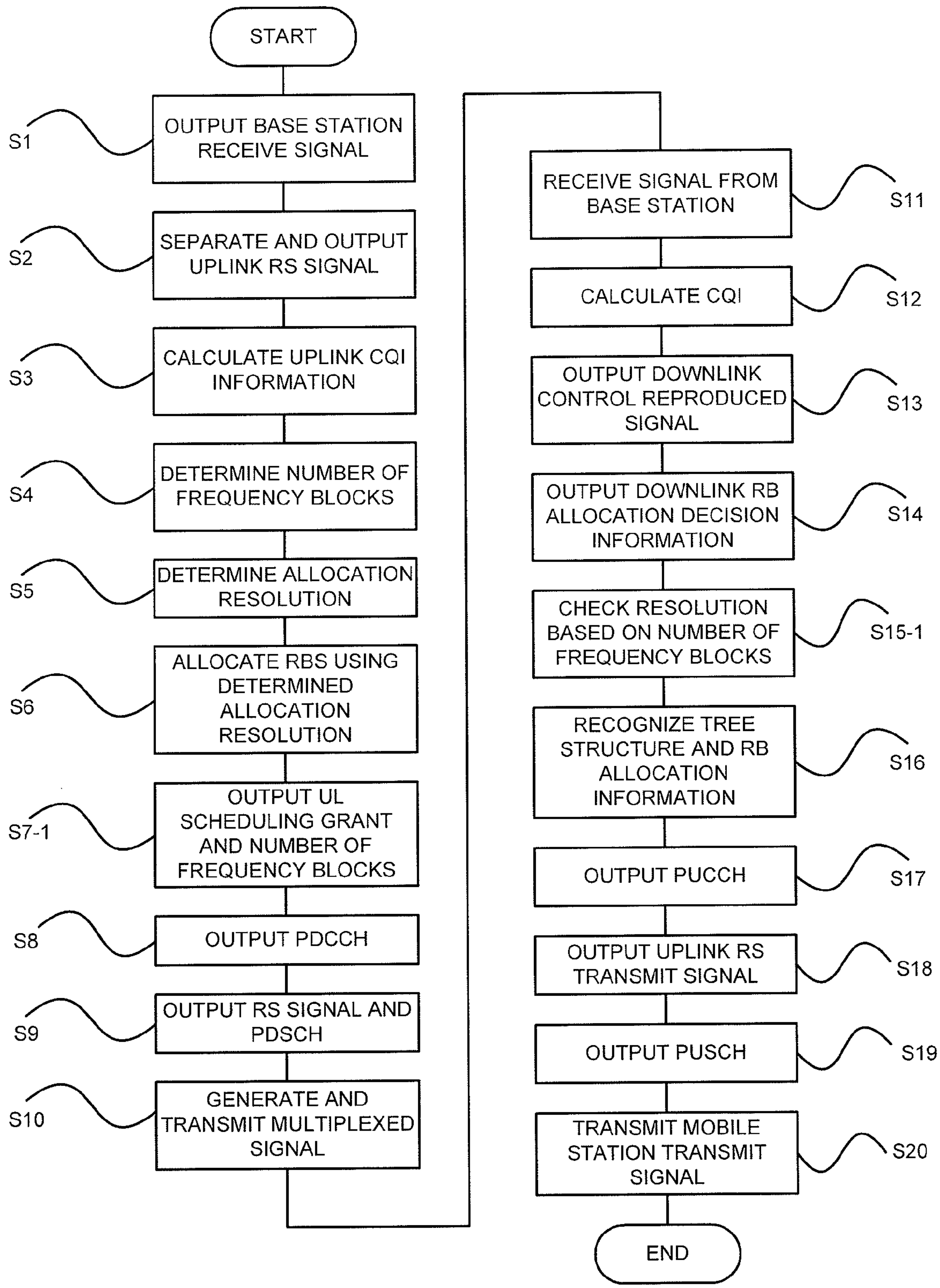
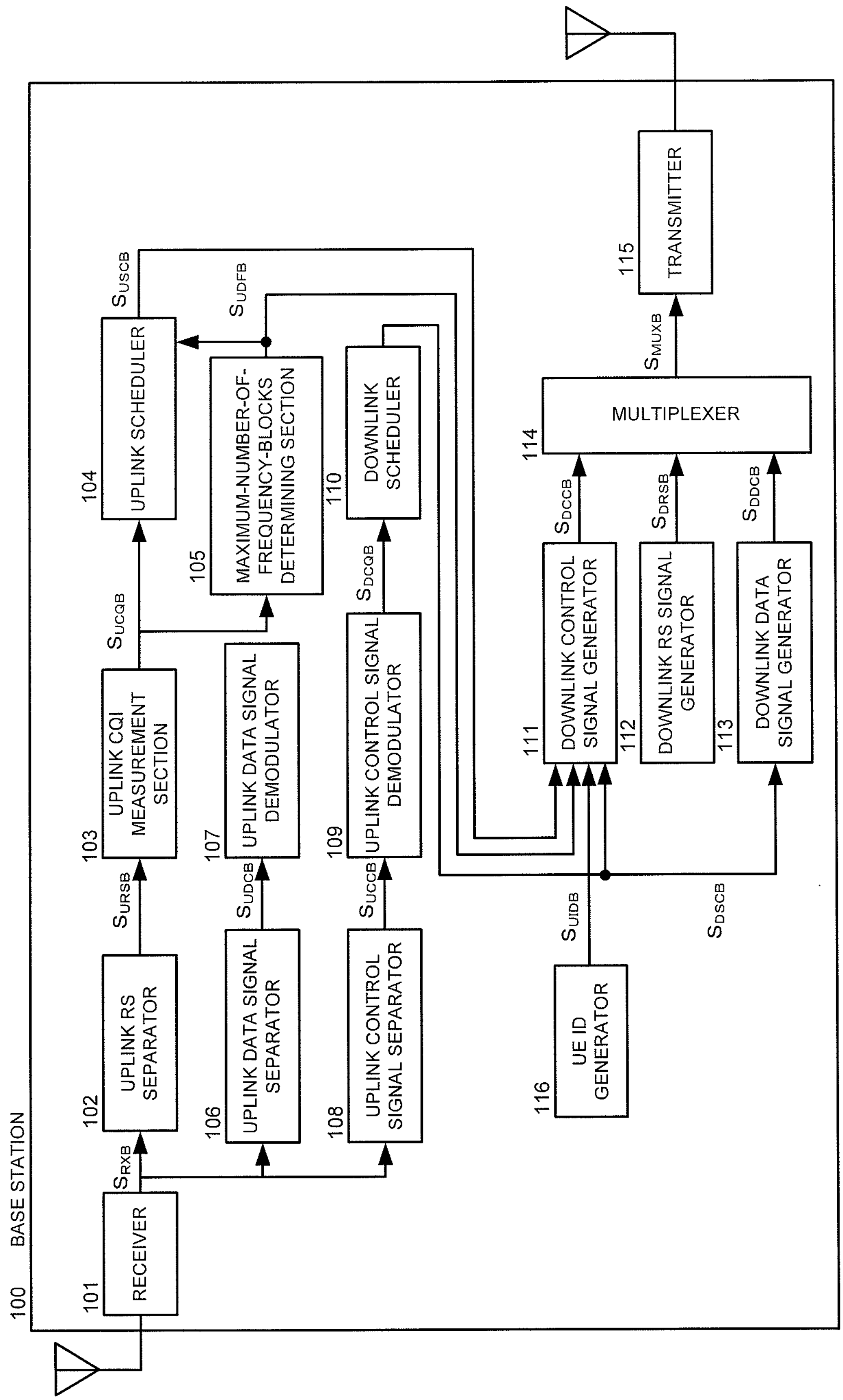

START
S1
OUTPUT BASE STATION RECEIVE SIGNAL
S2
SEPARATE AND OUTPUT UPLINK RS SIGNAL
S3
CALCULATE UPLINK CQI INFORMATION
S4
DETERMINE NUMBER OF FREQUENCY BLOCKS
S5
DETERMINE ALLOCATION RESOLUTION
S6
ALLOCATE RBS USING DETERMINED ALLOCATION RESOLUTION
S7-1
OUTPUT UL SCHEDULING GRANT AND NUMBER OF FREQUENCY BLOCKS
S8
OUTPUT PDCCH
S9
OUTPUT RS SIGNAL AND PDSCH
S10
GENERATE AND TRANSMIT MULTIPLEXED SIGNAL
RECEIVE SIGNAL FROM BASE STATION
S11
CALCULATE CQI
S12
OUTPUT DOWNLINK CONTROL REPRODUCED SIGNAL
S13
OUTPUT DOWNLINK RB ALLOCATION DECISION INFORMATION
S14
CHECK RESOLUTION BASED ON NUMBER OF FREQUENCY BLOCKS
S15-1
RECOGNIZE TREE STRUCTURE AND RB ALLOCATION INFORMATION
S16
OUTPUT PUCCH
S17
OUTPUT UPLINK RS TRANSMIT SIGNAL
S18
OUTPUT PUSCH
S19
TRANSMIT MOBILE STATION TRANSMIT SIGNAL
S20
END

FIG. 13



BASE STATION
100
101
RECEIVER
S_{RXB}
102
UPLINK RS SEPARATOR
S_{URSB}
103
UPLINK CQI MEASUREMENT SECTION
S_{UCQB}
104
UPLINK SCHEDULER
S_{USCB}
105
MAXIMUM-NUMBER-OF-FREQUENCY-BLOCKS DETERMINING SECTION
S_{UDFB}
106
UPLINK DATA SIGNAL SEPARATOR
S_{UDCB}
107
UPLINK DATA SIGNAL DEMODULATOR
108
UPLINK CONTROL SIGNAL SEPARATOR
S_{UCCB}
109
UPLINK CONTROL SIGNAL DEMODULATOR
S_{DCQB}
110
DOWNLINK SCHEDULER
111
DOWNLINK CONTROL SIGNAL GENERATOR
S_{DCCB}
112
DOWNLINK RS SIGNAL GENERATOR
S_{DRSB}
113
DOWNLINK DATA SIGNAL GENERATOR
S_{DDCB}
114
MULTIPLEXER
S_{MUXB}
115
TRANSMITTER
116
UE ID GENERATOR
S_{UIDB}
S_{DSCB}

FIG. 14

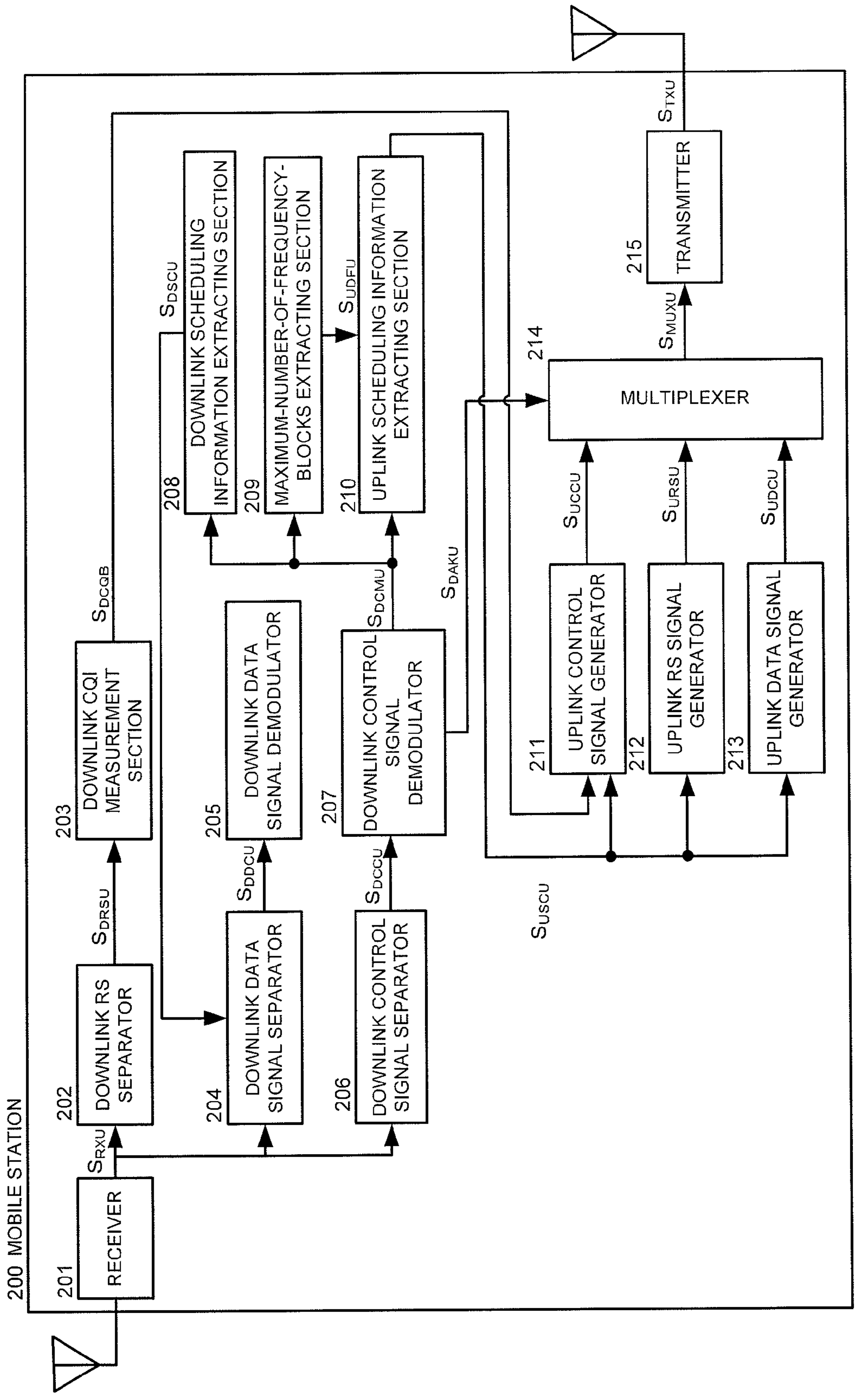

200 MOBILE STATION
201 RECEIVER
202 DOWNLINK RS SEPARATOR
203 DOWNLINK CQI MEASUREMENT SECTION
204 DOWNLINK DATA SIGNAL SEPARATOR
205 DOWNLINK DATA SIGNAL DEMODULATOR
206 DOWNLINK CONTROL SIGNAL SEPARATOR
207 DOWNLINK CONTROL SIGNAL DEMODULATOR
208 DOWNLINK SCHEDULING INFORMATION EXTRACTING SECTION
209 MAXIMUM-NUMBER-OF-FREQUENCY-BLOCKS EXTRACTING SECTION
210 UPLINK SCHEDULING INFORMATION EXTRACTING SECTION
211 UPLINK CONTROL SIGNAL GENERATOR
212 UPLINK RS SIGNAL GENERATOR
213 UPLINK DATA SIGNAL GENERATOR
214 MULTIPLEXER
215 TRANSMITTER
S_{RXU}
S_{DRSU}
S_{DCQB}
S_{DDCU}
S_{DCCU}
S_{DCMU}
S_{DSCU}
S_{UDFU}
S_{DAKU}
S_{USCU}
S_{UCCU}
S_{URSU}
S_{UDCU}
S_{MUXU}
S_{TXU}

FIG. 15

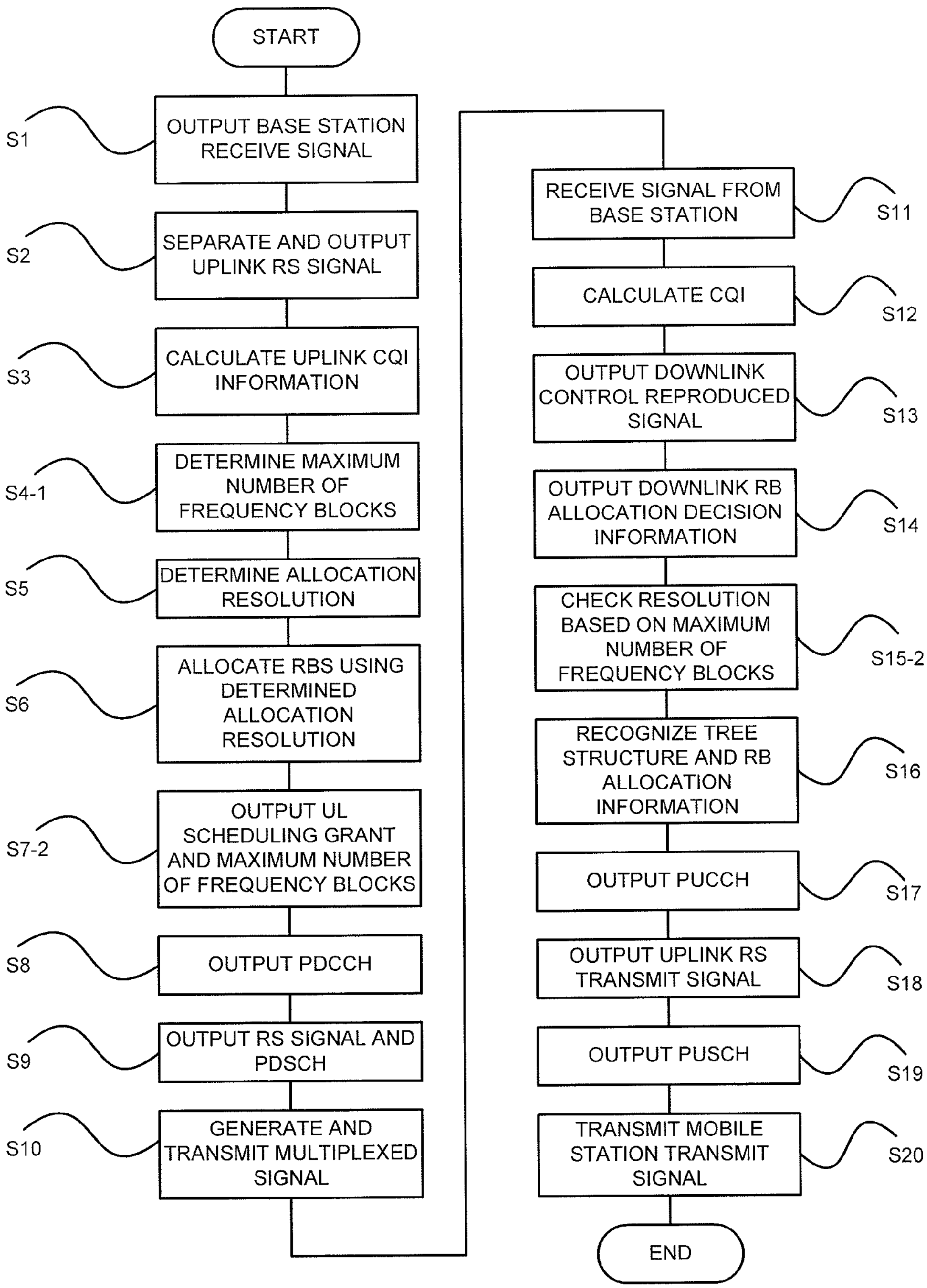

START
OUTPUT BASE STATION RECEIVE SIGNAL
S1
SEPARATE AND OUTPUT UPLINK RS SIGNAL
S2
CALCULATE UPLINK CQI INFORMATION
S3
DETERMINE MAXIMUM NUMBER OF FREQUENCY BLOCKS
S4-1
DETERMINE ALLOCATION RESOLUTION
S5
ALLOCATE RBS USING DETERMINED ALLOCATION RESOLUTION
S6
OUTPUT UL SCHEDULING GRANT AND MAXIMUM NUMBER OF FREQUENCY BLOCKS
S7-2
OUTPUT PDCCH
S8
OUTPUT RS SIGNAL AND PDSCH
S9
GENERATE AND TRANSMIT MULTIPLEXED SIGNAL
S10
RECEIVE SIGNAL FROM BASE STATION
S11
CALCULATE CQI
S12
OUTPUT DOWNLINK CONTROL REPRODUCED SIGNAL
S13
OUTPUT DOWNLINK RB ALLOCATION DECISION INFORMATION
S14
CHECK RESOLUTION BASED ON MAXIMUM NUMBER OF FREQUENCY BLOCKS
S15-2
RECOGNIZE TREE STRUCTURE AND RB ALLOCATION INFORMATION
S16
OUTPUT PUCCH
S17
OUTPUT UPLINK RS TRANSMIT SIGNAL
S18
OUTPUT PUSCH
S19
TRANSMIT MOBILE STATION TRANSMIT SIGNAL
S20
END

FIG. 16

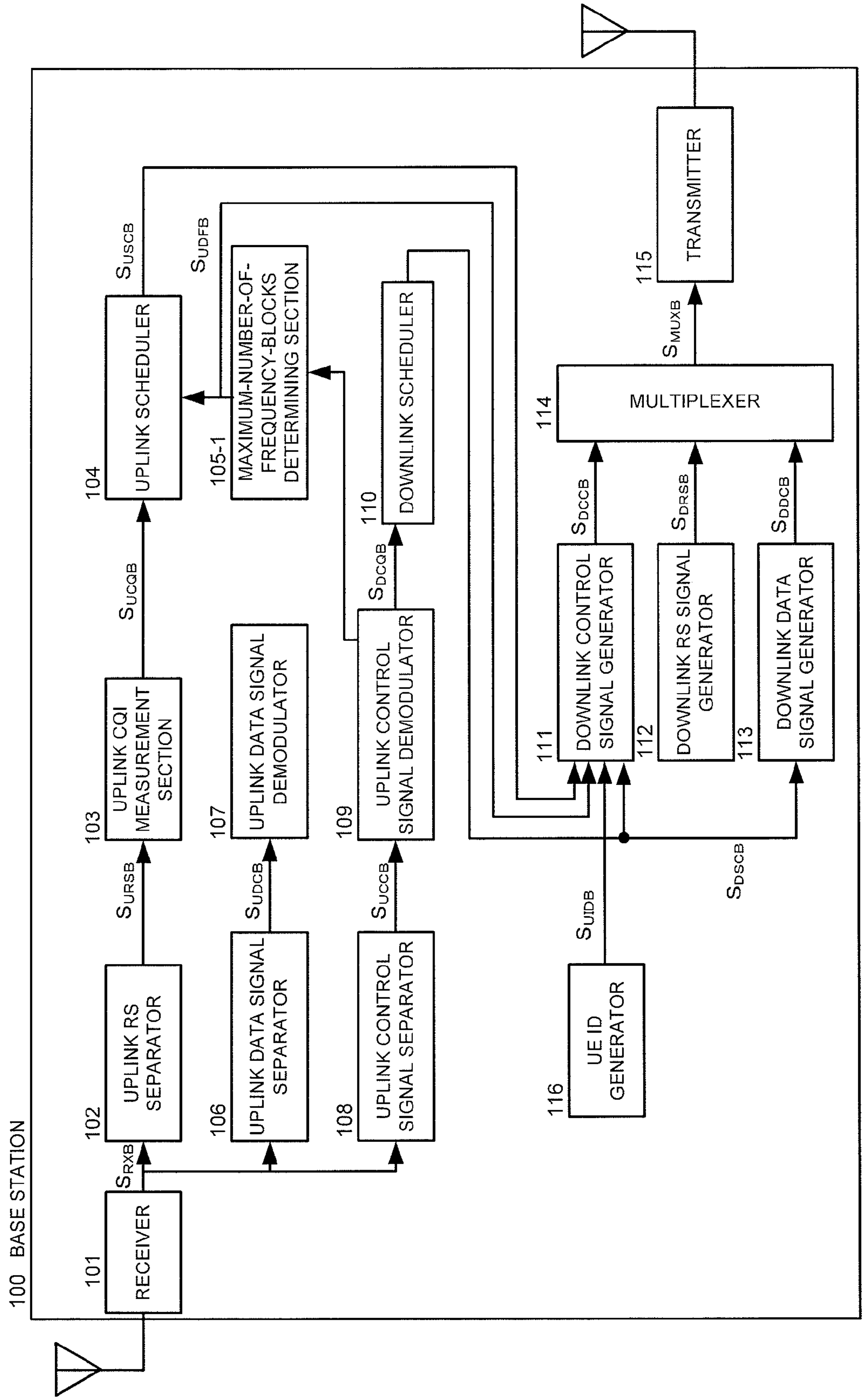

100 BASE STATION
101 RECEIVER
S_{RXB}
102 UPLINK RS SEPARATOR
S_{URSB}
103 UPLINK CQI MEASUREMENT SECTION
S_{UCQB}
104 UPLINK SCHEDULER
S_{USCB}
105-1 MAXIMUM-NUMBER-OF-FREQUENCY-BLOCKS DETERMINING SECTION
S_{UDFB}
106 UPLINK DATA SIGNAL SEPARATOR
S_{UDCB}
107 UPLINK DATA SIGNAL DEMODULATOR
108 UPLINK CONTROL SIGNAL SEPARATOR
S_{UCCB}
109 UPLINK CONTROL SIGNAL DEMODULATOR
S_{DCQB}
110 DOWNLINK SCHEDULER
111 DOWNLINK CONTROL SIGNAL GENERATOR
S_{DCCB}
112 DOWNLINK RS SIGNAL GENERATOR
S_{DRSB}
113 DOWNLINK DATA SIGNAL GENERATOR
S_{DDCB}
114 MULTIPLEXER
S_{MUXB}
115 TRANSMITTER
116 UE ID GENERATOR
S_{UIDB}
S_{DSCB}

FIG. 17

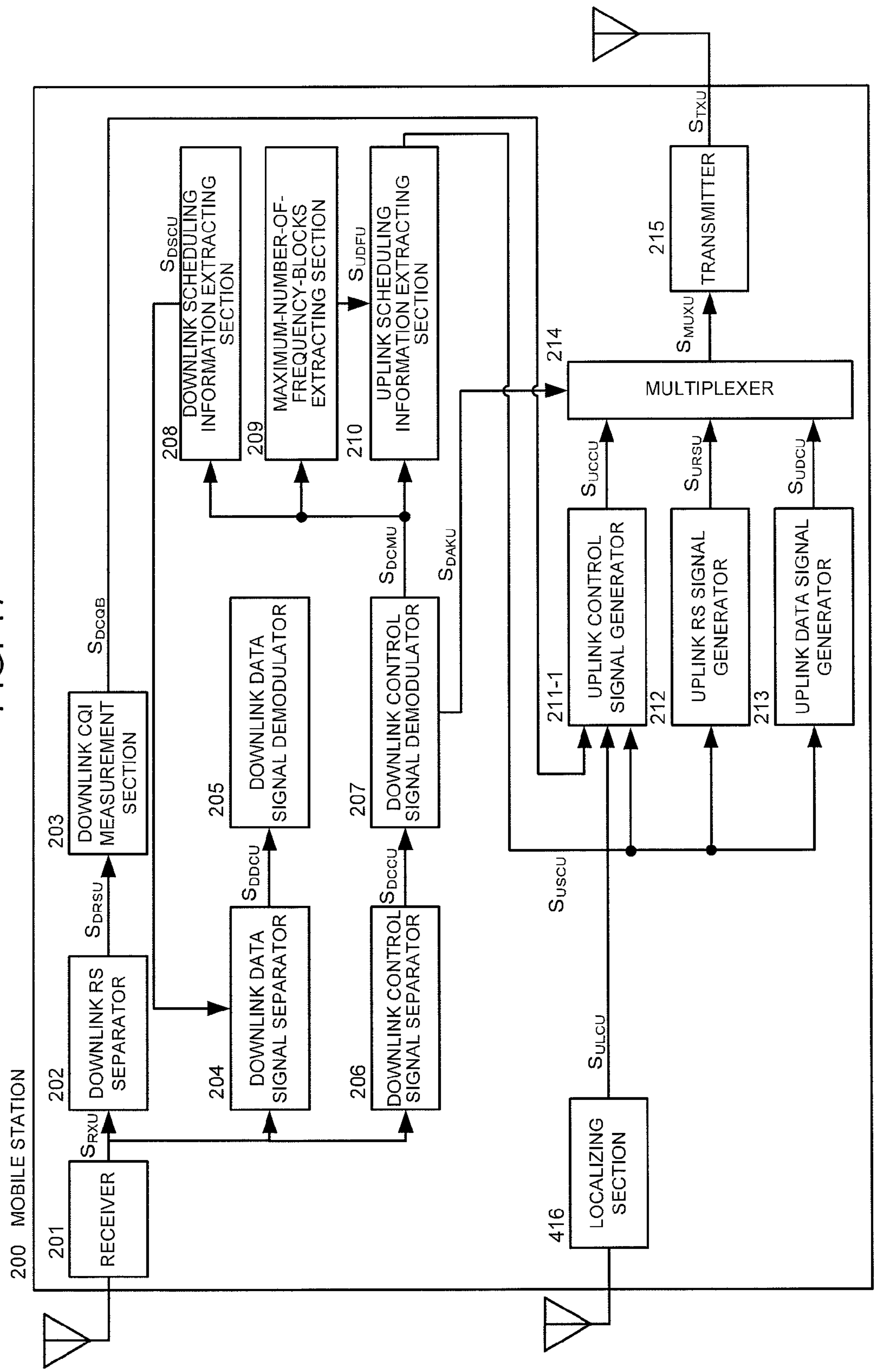

200 MOBILE STATION
201
RECEIVER
S_{RXU}
202
DOWNLINK RS SEPARATOR
S_{DRSU}
203
DOWNLINK CQI MEASUREMENT SECTION
S_{DCQB}
204
DOWNLINK DATA SIGNAL SEPARATOR
S_{DDCU}
205
DOWNLINK DATA SIGNAL DEMODULATOR
206
DOWNLINK CONTROL SIGNAL SEPARATOR
S_{DCCU}
207
DOWNLINK CONTROL SIGNAL DEMODULATOR
S_{DCMU}
S_{DAKU}
208
DOWNLINK SCHEDULING INFORMATION EXTRACTING SECTION
S_{DSCU}
209
MAXIMUM-NUMBER-OF-FREQUENCY-BLOCKS EXTRACTING SECTION
S_{UDFU}
210
UPLINK SCHEDULING INFORMATION EXTRACTING SECTION
211-1
UPLINK CONTROL SIGNAL GENERATOR
S_{UCCU}
212
UPLINK RS SIGNAL GENERATOR
S_{URSU}
213
UPLINK DATA SIGNAL GENERATOR
S_{UDCU}
S_{USCU}
214
MULTIPLEXER
S_{MUXU}
215
TRANSMITTER
S_{TXU}
416
LOCALIZING SECTION
S_{ULCU}

FIG. 18

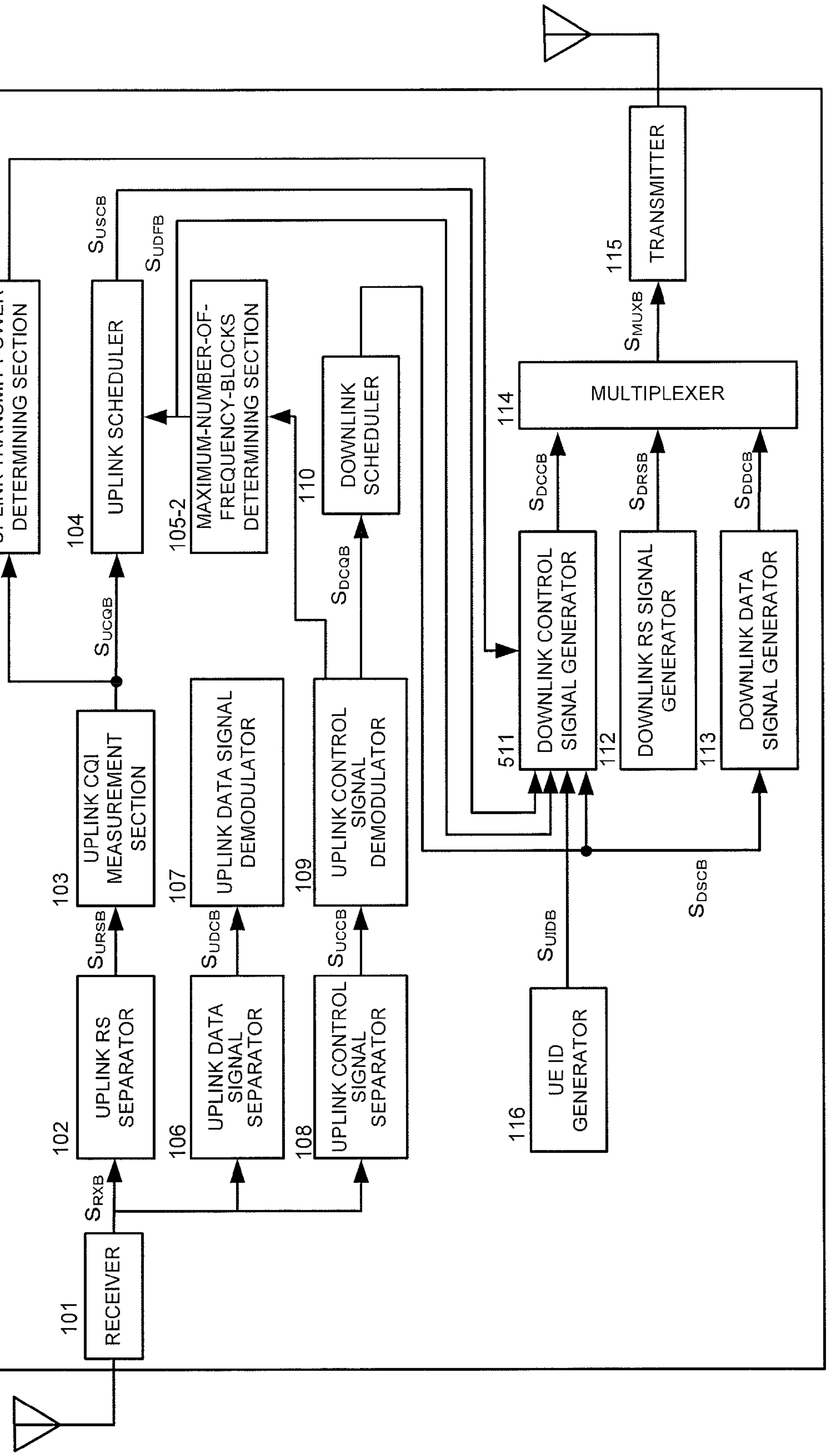

100 BASE STATION
101 RECEIVER
S_{RXB}
102 UPLINK RS SEPARATOR
106 UPLINK DATA SIGNAL SEPARATOR
108 UPLINK CONTROL SIGNAL SEPARATOR
S_{URSB}
S_{UDCB}
S_{UCCB}
103 UPLINK CQI MEASUREMENT SECTION
107 UPLINK DATA SIGNAL DEMODULATOR
109 UPLINK CONTROL SIGNAL DEMODULATOR
S_{UCQB}
S_{DCQB}
517 UPLINK TRANSMIT POWER DETERMINING SECTION
104 UPLINK SCHEDULER
105-2 MAXIMUM-NUMBER-OF-FREQUENCY-BLOCKS DETERMINING SECTION
110 DOWNLINK SCHEDULER
S_{UPWB}
S_{USCB}
S_{UDFB}
116 UE ID GENERATOR
S_{UIDB}
S_{DSCB}
511 DOWNLINK CONTROL SIGNAL GENERATOR
112 DOWNLINK RS SIGNAL GENERATOR
113 DOWNLINK DATA SIGNAL GENERATOR
S_{DCCB}
S_{DRSB}
S_{DDCB}
114 MULTIPLEXER
S_{MUXB}
115 TRANSMITTER

FIG. 19

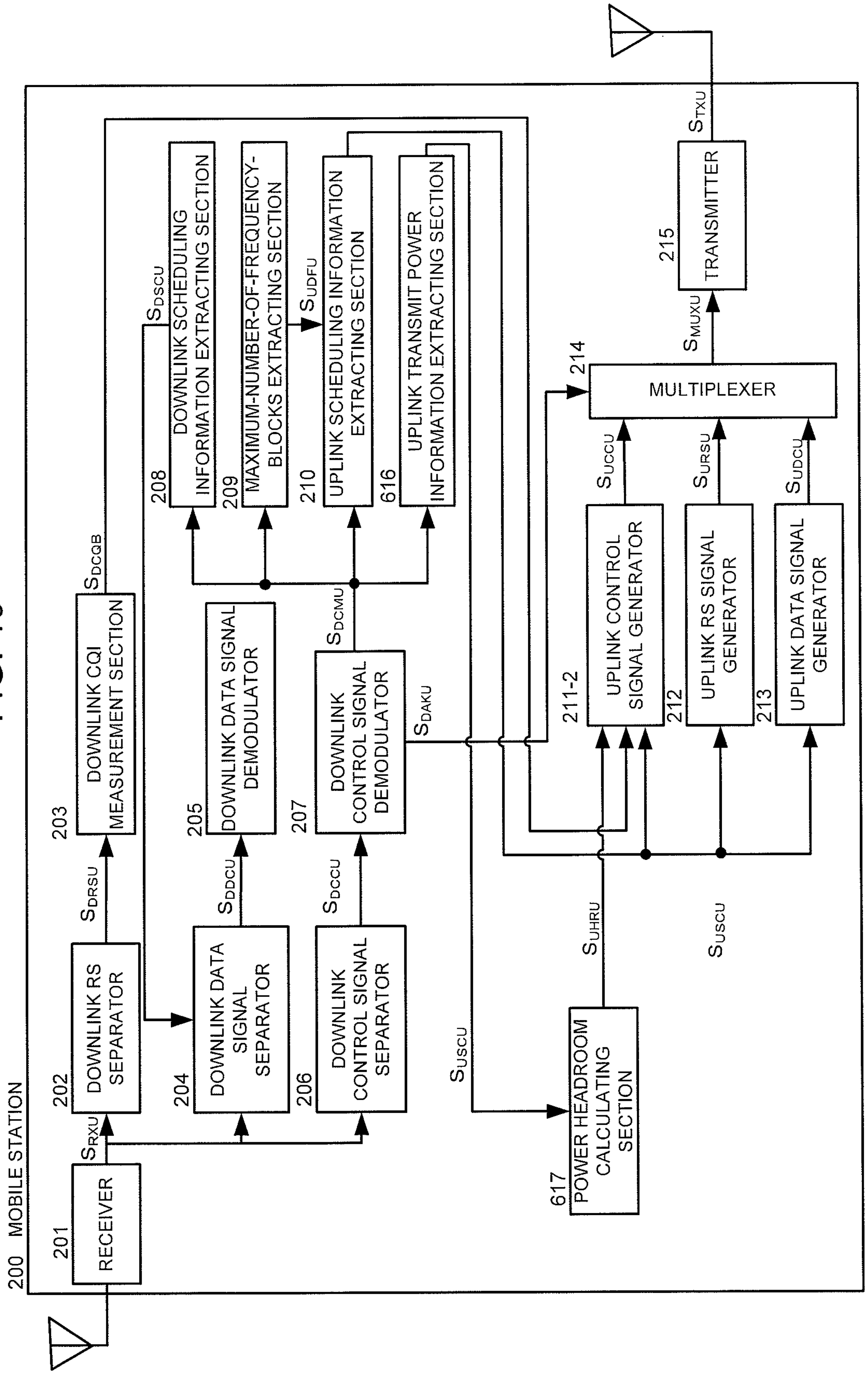

200 MOBILE STATION
201 RECEIVER
202 DOWNLINK RS SEPARATOR
203 DOWNLINK CQI MEASUREMENT SECTION
204 DOWNLINK DATA SIGNAL SEPARATOR
205 DOWNLINK DATA SIGNAL DEMODULATOR
206 DOWNLINK CONTROL SIGNAL SEPARATOR
207 DOWNLINK CONTROL SIGNAL DEMODULATOR
208 DOWNLINK SCHEDULING INFORMATION EXTRACTING SECTION
209 MAXIMUM-NUMBER-OF-FREQUENCY-BLOCKS EXTRACTING SECTION
210 UPLINK SCHEDULING INFORMATION EXTRACTING SECTION
616 UPLINK TRANSMIT POWER INFORMATION EXTRACTING SECTION
211-2 UPLINK CONTROL SIGNAL GENERATOR
212 UPLINK RS SIGNAL GENERATOR
213 UPLINK DATA SIGNAL GENERATOR
214 MULTIPLEXER
215 TRANSMITTER
617 POWER HEADROOM CALCULATING SECTION
S_{RXU}
S_{DRSU}
S_{DDCU}
S_{DCCU}
S_{DCQB}
S_{DSCU}
S_{UDFU}
S_{DCMU}
S_{DAKU}
S_{USCU}
S_{UHRU}
S_{USCU}
S_{UCCU}
S_{URSU}
S_{UDCU}
S_{MUXU}
S_{TXU}

FIG. 20

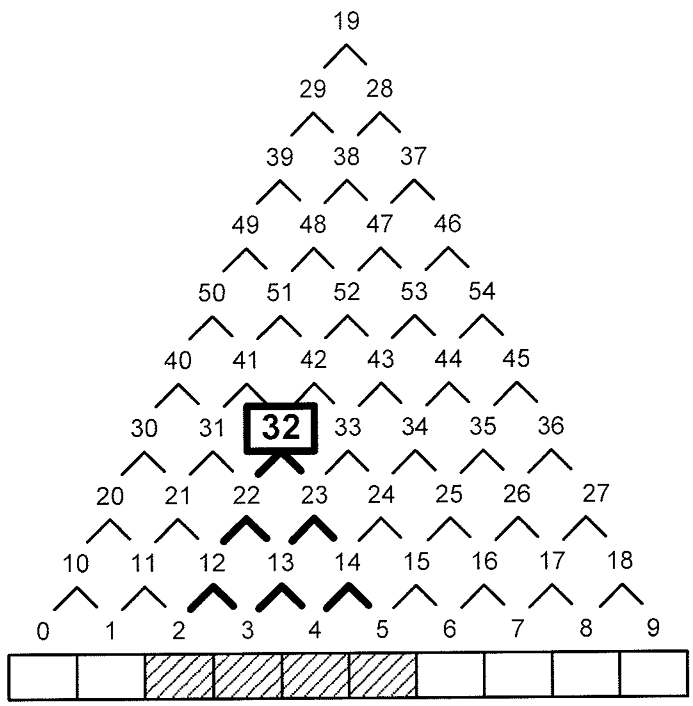

19
29 28
39 38 37
49 48 47 46
50 51 52 53 54
40 41 42 43 44 45
30 31 32 33 34 35 36
20 21 22 23 24 25 26 27
10 11 12 13 14 15 16 17 18
0 1 2 3 4 5 6 7 8 9

FIG. 21

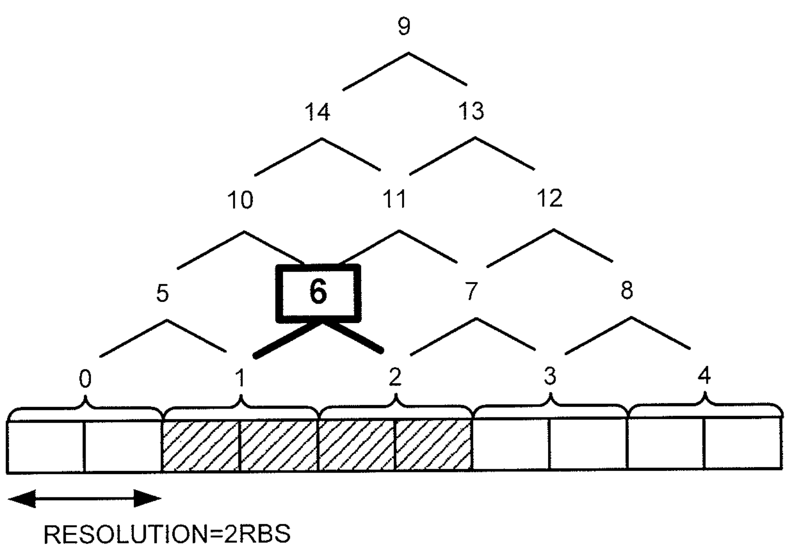

9
14 13
10 11 12
5 6 7 8
0 1 2 3 4
RESOLUTION=2RBS

FIG. 22

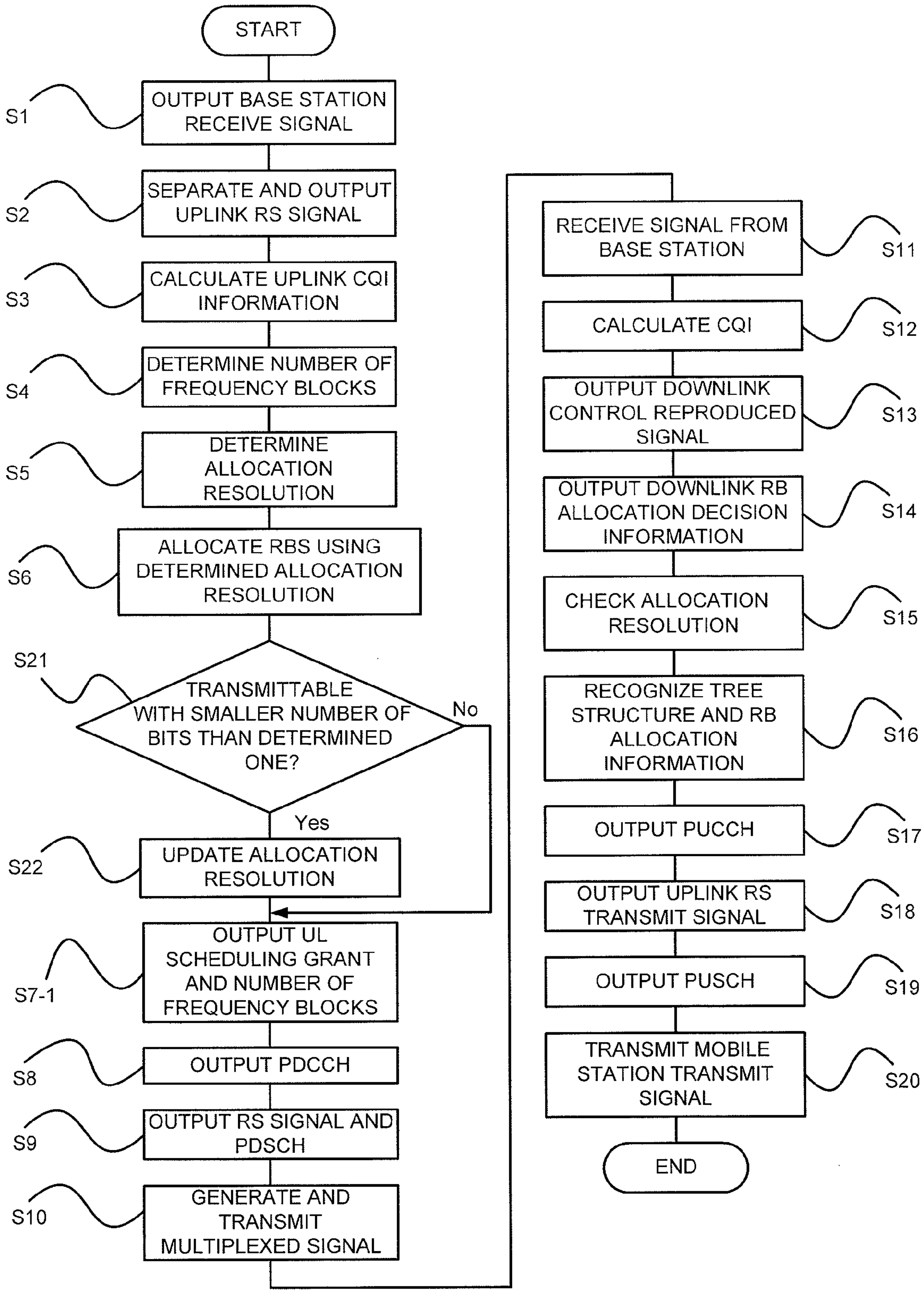
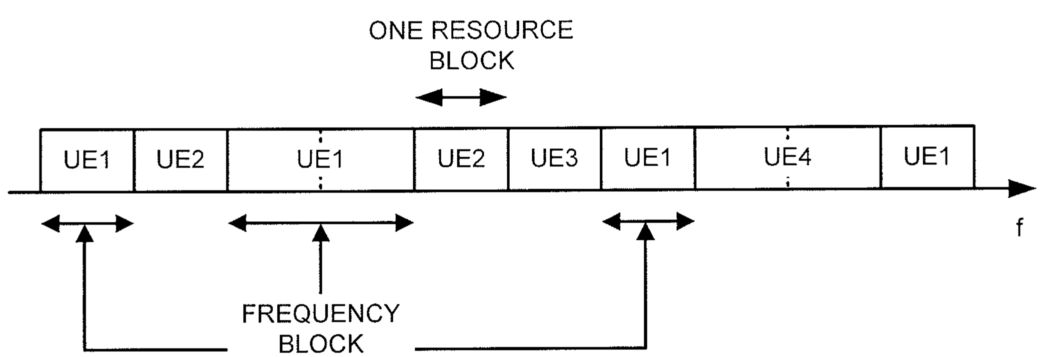

START
S1
OUTPUT BASE STATION RECEIVE SIGNAL
S2
SEPARATE AND OUTPUT UPLINK RS SIGNAL
S3
CALCULATE UPLINK CQI INFORMATION
S4
DETERMINE NUMBER OF FREQUENCY BLOCKS
S5
DETERMINE ALLOCATION RESOLUTION
S6
ALLOCATE RBS USING DETERMINED ALLOCATION RESOLUTION
S21
TRANSMITTABLE WITH SMALLER NUMBER OF BITS THAN DETERMINED ONE?
No
Yes
S22
UPDATE ALLOCATION RESOLUTION
S7-1
OUTPUT UL SCHEDULING GRANT AND NUMBER OF FREQUENCY BLOCKS
S8
OUTPUT PDCCH
S9
OUTPUT RS SIGNAL AND PDSCH
S10
GENERATE AND TRANSMIT MULTIPLEXED SIGNAL
RECEIVE SIGNAL FROM BASE STATION
S11
CALCULATE CQI
S12
OUTPUT DOWNLINK CONTROL REPRODUCED SIGNAL
S13
OUTPUT DOWNLINK RB ALLOCATION DECISION INFORMATION
S14
CHECK ALLOCATION RESOLUTION
S15
RECOGNIZE TREE STRUCTURE AND RB ALLOCATION INFORMATION
S16
OUTPUT PUCCH
S17
OUTPUT UPLINK RS TRANSMIT SIGNAL
S18
OUTPUT PUSCH
S19
TRANSMIT MOBILE STATION TRANSMIT SIGNAL
S20
END

FIG. 23


ONE RESOURCE
BLOCK
UE1
UE2
UE1
UE2
UE3
UE1
UE4
UE1
f
FREQUENCY
BLOCK

RESOURCE ALLOCATION METHOD, IDENTIFICATION METHOD, RADIO COMMUNICATION SYSTEM, BASE STATION, MOBILE STATION, AND PROGRAM

CROSS REFERENCE TO RELATED APPLICATIONS

This application is a National Stage of International Application No. PCT/JP2009/061194 filed Jun. 19, 2009, which claims priority from Japanese Patent Application No. 2008-161752 filed Jun. 20, 2008, the contents of all of which are incorporated herein by reference in their entirety.

TECHNICAL FIELD

The present invention relates to a technique for notifying resource allocation information in scheduling.

BACKGROUND ART

For uplink according to LTE (Long Term Evolution) in 3GPP (3^{rd} Generation Partnership Project), an SC (single-carrier)-FDMA (Frequency Division Multiple Access) scheme is adopted for a wireless access scheme to avoid an increase in PAPR (Peak to Average Power Ratio) and achieve wide coverage. According to SC-FDMA, only one frequency block can be allocated per mobile station within one Transmit Time Interval (TTI), where a frequency block is composed of resource blocks (each composed of a plurality of sub-carriers) that are consecutive on the frequency axis. When the number of frequency blocks is thus small, a Tree-Based (see Non-patent Document 1) method can minimize the amount of information on resource allocation. Accordingly, the Tree-Based method is employed in notification of uplink resource allocation information (Uplink Scheduling Grant) in scheduling for LTE uplink.

Non-patent Document 1: 3GPP R1-070881, NEC Group, NTT DoCoMo, "Uplink Resource Allocation for E-UTRA," February 2007.

DISCLOSURE OF THE INVENTION

Problems to be Solved by the Invention

In broadband wireless communications, influence of a plurality of delay paths causes frequency-selective phasing with which Channel Quality Indicator (CQI) varies on the frequency axis. Moreover, when considering multiple access in which a base station communicates with a plurality of mobile stations, the mobile stations communicate with the base station in different environments, so that CQI in the frequency domain is different from mobile station to mobile station. From such a background, an attempt is made to improve throughput in LTE by scheduling (frequency domain channel dependent scheduling) comprising comparing CQI in the frequency domain among mobile stations, and allocating a sub-carrier with excellent CQI to each mobile station.

When making the frequency domain channel dependent scheduling in SC-FDMA, only one frequency block (frequency block: at least one or more resource blocks consecutive on the frequency axis) with good CQI is allocated to one mobile station within 1 TTI. On the other hand, by making discontinuous sub-carrier allocation to increase the number of frequency blocks as in OFDM (Orthogonal Frequency Division Multiplexing) adopted in an LTE downlink access

scheme, an additional multi-diversity effect can be achieved to improve throughput. However, an increased number of frequency blocks may cause an increase of overhead due to notification of information on resource block allocation (Scheduling Grant).

In fact, adoption of a Bit Map method (a method suitable for a larger number of frequency blocks) is currently being studied in notification of resource block allocation information in LTE downlink (Downlink Scheduling Grant). The Bit Map method has a greater overhead than that in the Tree-Based method (a method suitable for a smaller number of frequency blocks) for use in notification of LTE uplink RB allocation information (Uplink Scheduling Grant). In particular, resource allocation of 100 RBs requires 100-bit scheduling information when using the Bit Map method regardless the number of frequency blocks.

On the other hand, when using the Tree-Based method, only $\log_2 100\ (100+1)/2=13$-bit scheduling information is required for a number of frequency blocks of one; however, as the number of frequency blocks becomes larger, an amount of information multiplied by the number of frequency blocks is required, as compared with a case in which the number of frequency blocks is one. In particular, while the overhead in using the Tree-Based method for a number of frequency blocks=1 is 13 bits as described above, it increases up to 13×2=26 bits for a number of frequency blocks=2, and to 13×4=52 bits for a number of frequency blocks=4. As such, the number of RB allocation patterns is generally larger for an increased number of frequency blocks, and accordingly, the amount of information for Uplink Scheduling Grant becomes greater. Therefore, there is a problem that to enhance the effect of frequency scheduling, the signaling overhead increases relative to a smaller number of frequency blocks.

It is therefore a problem to be solved by the present invention is to provide a technique for avoiding the signaling overhead for scheduling information encountered in enhancing the effect of multi-user diversity.

Means for Solving the Problems

An aspect of the present invention for solving the aforementioned problem is a resource allocating method, characterized in comprising: determining an allocation resolution that is a unit of resource block allocation, when allocating at least one or more resource block groups including at least one or more resource blocks consecutive on a frequency axis to a terminal.

Another aspect of the present invention for solving the aforementioned problem is a scheduling information identifying method, characterized in comprising: identifying, from an allocation resolution that is a unit of resource block allocation, which is determined when allocating at least one or more resource block groups including at least one or more resource blocks consecutive on a frequency axis, the allocated resource blocks.

Still another aspect of the present invention for solving the aforementioned problem is a wireless system comprising: scheduling means for determining an allocation resolution that is a unit of resource block allocation, when allocating at least one or more resource block groups including at least one or more resource blocks consecutive on a frequency axis to a terminal.

Still another aspect of the present invention for solving the aforementioned problem is a base station, characterized in comprising: scheduling means for determining an allocation resolution that is a unit of resource block allocation, when allocating at least one or more resource block groups including at least one or more resource blocks consecutive on a frequency axis to a terminal.

Still another aspect of the present invention for solving the aforementioned problem is a mobile station comprising: identifying, from an allocation resolution that is a unit of resource block allocation, which is determined when allocating at least one or more resource block groups including at least one or more resource blocks consecutive on a frequency axis, the allocated resource blocks.

Still another aspect of the present invention for solving the aforementioned problem is a program for a base station, said program causing said base station to execute: determining processing of determining an allocation resolution that is a unit of resource block allocation, when allocating at least one or more resource block groups including at least one or more resource blocks consecutive on a frequency axis to a terminal.

Still another aspect of the present invention for solving the aforementioned problem is a program for a mobile station, said program causing said mobile station to execute: processing of identifying, from an allocation resolution that is a unit of resource block allocation, which is determined when allocating at least one or more resource block groups including at least one or more resource blocks consecutive on a frequency axis, the allocated resource blocks.

Effects of the Invention

According to the present invention, an allocation resolution suitable to circumstances is determined, a structure in the Tree-Based method is modified accordingly, and information on allocated RBs is represented using the Tree-Based method; therefore, an increase of the amount of signaling with an increase of the number of frequency blocks can be prevented.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** A block diagram of a base station in a wireless communication system in a first embodiment.

FIG. **2** A block diagram of a mobile station in the wireless communication system in the first embodiment.

FIG. **3** An example of a correspondence table for a frequency block and an allocation resolution.

FIG. **4** A diagram showing an example of RBs allocated to a mobile station.

FIG. **5** A diagram showing an example of RBs allocated to UE**1** and UL Scheduling Grant.

FIG. **6** A diagram showing an example of RBs allocated to UE**2** and UL Scheduling Grant.

FIG. **7** A diagram showing an example of an RB allocated to UE**3** and UL Scheduling Grant.

FIG. **8** A diagram showing an example of an RB allocated to UE**4** and UL Scheduling Grant.

FIG. **9** A diagram for explaining the Tree-Based method modified according to an allocation resolution.

FIG. **10** A flow chart of the first embodiment.

FIG. **11** A diagram showing the number of bits of resource allocation information with respect to the maximum frequency blocks and allocation resolution.

FIG. **12** A flow chart of a second embodiment.

FIG. **13** A block diagram of a base station in a wireless communication system in a third embodiment.

FIG. **14** A block diagram of a mobile station in the wireless communication system in the third embodiment.

FIG. **15** A flow chart of the third embodiment.

FIG. **16** Another block diagram of a base station in the wireless communication system in the third embodiment.

FIG. **17** Another block diagram of a mobile station in the wireless communication system in the third embodiment.

FIG. **18** Another block diagram of a base station in the wireless communication system in the third embodiment.

FIG. **19** Another block diagram of a mobile station in the wireless communication system in the third embodiment.

FIG. **20** A diagram for explaining resource block allocation.

FIG. **21** A diagram for explaining resource block allocation.

FIG. **22** A flow chart of a fourth embodiment.

FIG. **23** A diagram for explaining frequency blocks.

EXPLANATION OF SYMBOLS

100 Base station
101 Receiver
102 Uplink RS separator
103 Uplink CQI measurement section
104 Uplink scheduler
105 Maximum-number-of-frequency-blocks determining section
106 Uplink data signal separator
107 Uplink data signal demodulator
108 Uplink control signal separator
109 Uplink control signal demodulator
110 Downlink scheduler
111 Downlink control signal generator
112 Downlink RS signal generator
113 Downlink data signal generator
114 Multiplexer
115 Transmitter
116 UE ID generator
200 Mobile station
201 Receiver
202 Downlink RS separator
203 Downlink CQI measurement section
204 Downlink data signal separator
205 Downlink data signal demodulator
206 Downlink control signal separator
207 Downlink control signal demodulator
208 Downlink scheduling information extracting section
209 Maximum-number-of-frequency-blocks extracting section
210 Uplink scheduling information extracting section
211 Uplink control signal generator
212 Uplink RS signal generator
213 Uplink data signal generator
214 Multiplexer
215 Transmitter

BEST MODES FOR CARRYING OUT THE INVENTION

According to Long Term Evolution (LTE) being currently standardized in the 3rd Generation Partnership Project (3GPP), Orthogonal Frequency Division Multiplexing (OFDM) is adopted for a downlink access scheme. The frequency domain channel dependent scheduling is applied to LTE downlink, and a plurality of frequency blocks can be allocated per mobile station within one Transmit Time Interval (TTI), where a frequency block is a resource block group composed of at least one or more resource blocks (RBs: each of which is composed of a plurality of sub-carriers) that are consecutive on the frequency axis. FIG. **23** shows an example of frequency block allocation in LTE downlink scheduling. This represents a case in which four mobile stations are scheduled within one TTI in a system band. The number of frequency blocks for mobile station **1** (UE**1**) is three, the number of frequency blocks for mobile station **2** (UE**2**) is two, the frequency block for mobile station **3** (UE**3**) counts one and the frequency block for mobile station **4** (UE**4**) counts one.

The present invention is characterized in determining, when a base station that allocates a plurality of frequency blocks to one mobile station as described above allocates resource blocks to terminals, a minimal unit (which will be referred to as allocation resolution hereinbelow) for resource blocks to be allocated, and determining a structure in the Tree-Based method representing the allocated resource blocks. Now details of the present invention will be described below with reference to the accompanying drawings.

<First Embodiment>

The present embodiment will address a case in which a value of the resolution is determined in accordance with the number of frequency blocks determined in making scheduling (resource block allocation).

A block diagram of a base station in the present embodiment is shown in FIG. **1**, and that of a mobile station in FIG. **2**.

First, a configuration of a base station **100** will be described.

A receiver **101** in the base station **100** receives a signal from a mobile station **200**, establishes uplink synchronization using a guard interval, and outputs a base station receive signal S_{RXB}.

An uplink RS (Reference Signal) separator **102** separates from the base station receive signal S_{RXB} an uplink RS signal S_{URSB} in which uplink RS signals of a plurality of mobile stations are multiplexed, and outputs it.

An uplink CQI measurement section **103** receives the uplink RS signals S_{URSB} for a plurality of mobile stations as input, calculates CQI (Channel Quality Indicator) for each mobile station on an RB-by-RB basis, and outputs it as uplink CQI information S_{UCQB}.

An uplink scheduler **104** makes uplink scheduling for each mobile station. The uplink scheduler **104** determines a number of frequency blocks for resources to be allocated based on the uplink CQI information S_{UCQB}. In particular, for good CQI, a larger number of frequency blocks is determined, and for poor CQI, a smaller number of frequency blocks is determined. RBs are allocated with an allocation resolution determined in accordance with the determined number of frequency blocks and with the determined number of frequency blocks. Once the allocation resolution has been determined, a structure in the Tree-Based method representing positions of the allocated RBs is determined accordingly. The resource allocation information for each frequency block representing the positions of the allocated RBs in a Tree-Based form is combined with the value of the allocation resolution into one piece of scheduling information, that is, one piece of UL Scheduling Grant S_{USCB}, which is output in a number of bits in accordance with the determined structure in the Tree-Based method. The number of frequency blocks is also output as S_{UDFB}.

Now processing in the uplink scheduler **104** will be specifically described next.

The uplink scheduler **104** modifies and sets a minimal frequency bandwidth in resource allocation, that is, an allocation resolution, which is a minimal unit for resource block allocation, according to the number of frequency blocks determined based on the uplink CQI information S_{UCQB}. Specifically, a higher allocation resolution is set for a larger number of frequency blocks.

Next, a specific example will be described below, in which the number of signaling bits for use in resource allocation for one user is held down within 14 bits for a system band having 10 RBs.

Resource allocation at the uplink scheduler **104** is made using a correspondence table representing a relationship between the number of frequency blocks and allocation resolution, as shown in FIG. **3**. The correspondence table is defined depending upon a communication environment, etc. For example, a higher allocation resolution is defined for a larger number of frequency blocks. By using this relationship, it is possible to hold the number of signaling bits down to 14 bits including notification of the value of the allocation resolution (2 bits) for a number of frequency blocks of four or lower.

Assume that there are four mobile stations UE**1**, UE**2**, UE**3**, UE**4**, and the number of frequency blocks allocated to UE**1** is three, that allocated to UE**2** is two, that allocated to UE**3** is one, and that allocated to UE**4** is one. Now representing the resource blocks shown in FIG. **4** as RB**0**, RB**1**, . . . , RB**8**, RB**9** in sequence from left to right, it is assumed that scheduling is made to allocate RB**0**, RB**1**, RB**4**, RB**5**, RB**8** and RB**9** to UE**1**, RB**3** and RB**6** to UE**2**, RB**2** to UE**3**, and RB**7** to UE**4**. Here, a case in which the scheduling in FIG. **4** and relationship between the number of frequency blocks and allocation resolution in FIG. **3** are used will be described. FIGS. **5**, **6**, **7** and **8** show examples of RB allocation and UL Scheduling Grant using the Tree-Based method for UE**1**, UE**2**, UE**3** and UE**4**, respectively.

Since the number of frequency blocks is one for UE**3** and UE**4**, the allocation resolution is 1 RB with reference to the correspondence table in FIG. **3**. Therefore, when allocating resource blocks to UE**3** and UE**4**, they are allocated such that one resource block is allocated with a number of frequency blocks within one. To represent a resource corresponding to one frequency block within the whole band, 10 RBs, in the Tree-Based method with an allocation resolution of 1 RB, a value of any one of 1-55 is required (6 bits). Referring to FIGS. **7** and **8**, values of 1-55 representing resources of one frequency block are arranged in a tree structure. The tree structure in the Tree-Based method varies with the allocation resolution. In other words, the number of bits for UL Scheduling Grant also varies.

For example, referring to FIG. **9**, when the allocation resolution is 1 RB, the tree structure is constructed from a number sequence of 1-55 that can be expressed by 6 bits. When the allocation resolution is 2 RBs, allocation is made for each unit of two resource blocks, so that it can be handled with a number sequence similar to that for a system band of five RBs. Accordingly, the tree structure is constructed from a number sequence of 1-15. By correlating the tree structure with the determined number of frequency blocks in a one-to-one correspondence, and notifying the allocation resolution or number of frequency blocks to the mobile station, a tree structure in the Tree-Based method can be discriminated.

Since scheduling is made with only a number of frequency blocks=1 for UE**3** and UE**4**, they require a total of 8 bits (=1×6+2 bits) including notification of the value of the allocation resolution. Scheduling information on resource allocation (UL Scheduling Grant) to be notified to UE**3** has 8 bits, and a value of the allocation resolution of "1" and a position of "2" ("2" in FIG. **7**), which is the position of an allocated resource block represented in a tree structure, are notified thereto. UL Scheduling Grant for UE**4** has 8 bits, and a value of the allocation resolution of "1" and a position represented in a tree structure, "7" ("7" in FIG. **8**), are notified thereto.

For UE**2**, the number of frequency blocks is two, and therefore, the allocation resolution is 1 RB with reference to the correspondence table in FIG. **3**. To represent a resource corresponding to one frequency block within the whole band, 10 RBs, in the Tree-Based method with an allocation resolution of 1 RB, a value of any one of 1-55 that can be denoted by 6 bits is required. Since scheduling is made with two frequency blocks for UE**2**, it requires a total of 14 bits (=2×6+2 bits) including notification of the value of the allocation resolution. Then, UL Scheduling Grant for UE**2** has 14 bits, and a value of the allocation resolution of "1" and positions of allocated resource blocks represented in a tree structure, "3" and "6" ("3" and "6" in FIG. **6**), are notified thereto.

For UE**1**, the number of frequency blocks is three, and therefore, the allocation resolution is 2 RBs with reference to the correspondence table in FIG. **3**. To represent a resource corresponding to one frequency block within the whole band, 10 RBs, in the Tree-Based method with an allocation resolution of 2 RBs, a value of any one of 1-15, which can be denoted by 4 bits, is required. Since scheduling is made with three frequency blocks for UE**1**, it requires a total of 14 bits (=3×4+2 bits) including notification of the value of the allocation resolution. Then, UL Scheduling Grant for UE**1** has 14 bits, and a value of the allocation resolution of "2" and positions of allocated resource blocks represented in a tree structure, "0", "2" and "4" ("0", "2" and "4" in FIG. **5**) are notified thereto. By thus increasing the allocation resolution, the amount of information on resource allocation can be held down within 14 bits even for an increased number of frequency blocks.

Next, a general method of generating resource allocation information in a tree structure will be described. An example of an allocation resolution of P resource blocks (P is one or more) and a number of frequency blocks of n (n is one or more) will be described hereinbelow with reference to EQ. 1. In this example, one frequency block is defined as P (allocation resolution) consecutive resource blocks. Resource allocation information is composed of n resource indicator values (RIV's). The resource indicator value RIV_n for an n-th frequency block represents a frequency block at start ($RBG_{start,n}$) and a length of subsequent frequency blocks ($L_{CRBGs,n}$). The n-th resource indicator value RIV_n is defined by EQ. 1 below:

$$\begin{aligned}
&\text{if } (L_{CRBGs,n}-1) \le \lfloor N_{RBG}^{UL}/2 \rfloor \\
&\text{then } RIV_n = N_{RB}^{UL}(L_{CRBGs,n}-1) + RBG_{START,n} \\
&\text{else} \\
&RIV_n = N_{RBG}^{UL}(N_{RBG}^{UL} - L_{CRBGs,n}+1) + (N_{RBG}^{UL} - 1 - RBG_{START,n})
\end{aligned} \quad \text{(EQ. 1)}$$

where N^{UL}_{RBG} is the number of frequency blocks in the whole system.

The number of resource blocks in the whole system is N^{UL}_{RBG}×P (allocation resolution).

The thus-generated UL Scheduling Grant S_{USCB} is input to a downlink control signal generator **111**. The downlink control signal generator **111** is also supplied as input with DL Scheduling Grant S_{DSCB}, mobile station identification information S_{UIDB}, and frequency block signal S_{UDFB} with which the number of frequency blocks is indicated. The downlink control signal generator **111** multiplexes these input signals to generate a downlink control signal as PDCCH (Physical Downlink Control Channel) S_{DCCB}, and outputs it.

A downlink RS signal generator **112** generates a downlink RS signal and outputs it as a downlink RS signal S_{DRSB}.

A downlink data signal generator **113** receives the DL Scheduling Grant S_{DSCB} as input, multiplexes downlink data signals from a plurality of mobile stations in accordance with an RB pattern indicated by the DL Scheduling Grant S_{DSCB}, generates Physical Downlink Shared Channel (PDSCH) S_{DCCB}, and outputs it.

A multiplexer **114** receives the PDCCH S_{DCCB}, RS signal S_{DRSB} and PDSCH S_{DDCB} as input, multiplexes these signals to generate a downlink multiplexed signal S_{MUXB}, and outputs it.

A transmitter **115** receives the downlink multiplexed signal S_{MUXB} as input, generates a transmit signal S_{TXB}, and outputs it.

An uplink data signal separator **106** receives the base station receive signal S_{RXB} as input, extracts therefrom Physical Uplink Shared Channel (PUSCH) S_{UDCB} in which uplink data signals from a plurality of mobile stations are multiplexed, and outputs it. An uplink data signal demodulator **109** is supplied with the PUSCH S_{UDCB} as input, demodulates the PUSCH S_{UDCB}, and reproduces mobile station transmitted data.

An uplink control signal separator **108** receives the base station receive signal S_{RXB} as input, extracts therefrom Physical Uplink Control Channel (PUCCH) S_{UCCB} in which uplink control signals from a plurality of mobile stations are multiplexed, and outputs it. An uplink control signal demodulator **109** demodulates the PUCCH S_{UCCB}, and outputs a downlink CQI measurement signal S_{DCQB}, which is a result of measurement of downlink CQI transmitted by a plurality of mobile stations. A downlink scheduler **110** receives the downlink CQI measurement signal S_{DCQB} as input, makes downlink scheduling for a plurality of mobile stations, generates DL Scheduling Grant S_{DSCB}, which represents information on allocated RBs, and outputs it.

A UE ID generator **116** generates mobile station identification information S_{UIDB}, and outputs it.

Subsequently, a mobile station will be described. FIG. **2** is a block diagram showing a main configuration of a mobile station in the present embodiment.

A receiver **201** in a mobile station **200** receives a signal from the base station **100**, establishes downlink synchronization using a guard interval, and outputs a mobile station receive signal S_{RXU}.

A downlink RS (Reference Signal) separator **202** receives the mobile station receive signal S_{RXU} as input, separates therefrom a downlink RS signal S_{DRSU} in which downlink RS signals are multiplexed, and outputs it. A downlink CQI measurement section **203** receives the downlink RS signal S_{DRSU} as input, calculates CQI on an RB-by-RB basis, and outputs it as downlink CQI information S_{DCQB}.

A downlink control signal separator **206** receives the mobile station receive signal S_{RXU} as input, separates therefrom PDCCH S_{DCCU} in which downlink control signals from a plurality of mobile stations are multiplexed, and outputs it.

A downlink control signal demodulator **207** receives the PDCCH S_{DCCU} as input, demodulates the PDCCH S_{DCCU} to reproduce a downlink control signal, separates therefrom a result of reproduction in which mobile station identification information corresponding to the mobile station itself is multiplexed, and outputs it as a downlink control reproduced signal S_{DCMU}. It should be noted that only one PDCCH is multiplexed for the mobile station itself. Moreover, the downlink control signal demodulator **207** checks a result of demodulation of the PDCCH S_{DCCU} and reproduction of the downlink control signal as to whether it contains an error, in a case that no error is found, generates a signal indicating ACK, or otherwise, a signal indicating NACK as a downlink control signal decision signal S_{DAKU}, and outputs it. It should be noted that the downlink control signal decision signal S_{DAKU} is notified from the mobile station **200** to the base station **100**, and in a case that the downlink control signal decision signal S_{DAKU} is NACK, the base station **100** retransmits PDCCH corresponding to the mobile station **200**.

A downlink scheduling information extracting section **208** receives the downlink control reproduced signal S_{DCMU} as input, extracts therefrom downlink RB allocation decision information S_{DSCU} corresponding to downlink resource allocation information, and outputs it.

An uplink scheduling information extracting section **210** extracts, from the downlink control reproduced signal S_{DCMU}, UL Scheduling Grant that represents information on allocated uplink RBs. Next, it discriminates a tree structure in the Tree-Based method from the value of the allocation resolution contained in the UL Scheduling Grant, identifies an RB indicated by the uplink RB allocation information in this tree structure, and outputs it as uplink RB allocation decision information S_{USCU}.

An uplink control signal generator **211** receives the uplink RB allocation decision information S_{USCU} and downlink CQI information S_{DCQB} as input, generates Physical Uplink Control Channel (PUCCH) S_{UCCU} in which the downlink CQI information S_{DCQB} is multiplexed with a predetermined resource for a control signal indicated by the uplink RB allocation decision information S_{USCU}, and outputs it.

An uplink RS signal generator **212** receives the uplink RB allocation decision information S_{USCU} as input, generates an uplink RS transmit signal S_{URSU} using a predetermined resource for RS in the uplink RB allocation decision information S_{USCU}, and outputs it.

An uplink data signal generator **213** receives the uplink RB allocation decision information S_{USCU} as input, generates Physical Uplink Shared Channel (PUSCH) S_{UDCU} using a predetermined resource for a data signal in the uplink RB allocation decision information S_{USCU}, and outputs it.

A multiplexer **214** receives the PUCCH S_{UCCU}, uplink RS transmit signal S_{URSU}, PUSCH S_{UDCU} and downlink control signal decision signal S_{DAKU} as input, multiplexes these signals to generate a mobile station multiplexed signal S_{MUXU}, and outputs it. The transmitter **215** receives the mobile station multiplexed signal S_{MUXU} as input, generates a mobile station transmit signal S_{TUX}, and transmits it to the base station **100**.

A downlink data signal separator **204** receives the downlink RB allocation receive signal S_{DSCU} and mobile station receive signal S_{RXU} as input, separates therefrom PDSCH S_{DDCU} multiplexed with the downlink RB allocated to the mobile station itself based on the downlink RB allocation decision information S_{DSCU}, and outputs it. The downlink data signal demodulator **205** receives PDSCH S_{DDCU} as input, demodulates the PDSCH S_{DDCU}, and reproduces transmitted data from the base station to the mobile station itself.

Subsequently, an operation of the present embodiment will be described with reference to a flow chart in FIG. **10**.

The receiver **101** in the base station **100** receives a signal from the mobile station **200**, establishes uplink synchronization using a guard interval, and outputs a base station receive signal S_{RXB} (Step S**1**).

The uplink RS (Reference Signal) separator **102** separates from the output base station receive signal S_{RXB} an uplink RS signal S_{URSB} in which uplink RS signals from a plurality of mobile stations are multiplexed, and outputs it (Step S**2**).

From the uplink RS signals S_{URSB} for a plurality of mobile stations, the uplink CQI measurement section **103** calculates CQI (Channel Quality Indicator) for each mobile station on an RB-by-RB basis, and outputs it as uplink CQI information S_{UCQB} (Step S**3**).

The uplink scheduler **104** determines a number of frequency blocks for resources to be allocated to each mobile station based on the uplink CQI information S_{UCQB} for each mobile station (Step S**4**).

An allocation resolution correlated with the determined number of frequency blocks is determined using the correspondence table as shown in FIG. **3** kept in the equipment itself, whereby a structure in the Tree-Based method is determined, and the number of bits for UL Scheduling Grant is set as a number of bits in accordance with the determined structure in the Tree-Based method (Step S**5**).

RBs are allocated with resource blocks in a number equal to the determined allocation resolution and with the determined number of frequency blocks (Step S**6**).

Next, the uplink scheduler **104** outputs scheduling information representing positions of the allocated RBs in a Tree-Based form and the value of the allocation resolution in a specified number of bits as UL Scheduling Grant S_{USCB}, and outputs the number of frequency blocks as S_{UDFB} (Step S**7**).

The downlink control signal generator **111** is supplied as input with the UL Scheduling Grant S_{USCB}, DL Scheduling Grant S_{DSCB}, mobile station identification information S_{UIDB} and frequency block signal S_{UDFB}, multiplexes these input signals to generate a downlink control signal as PDCCH (Physical Downlink Control Channel) S_{DCCB}, and outputs it (Step S**8**).

The downlink RS signal generator **112** generates a downlink RS signal as a downlink RS signal S_{DRSB}, and outputs it; the downlink data signal generator **113** receives the DL Scheduling Grant S_{DSCB} as input, multiplexes downlink data signals from a plurality of mobile stations together in accordance with an RB pattern indicated by the DL Scheduling Grant S_{DSCB}, generates Physical Downlink Shared Channel (PDSCH) S_{DDCB}, and outputs it (Step S**9**).

The multiplexer **114** receives the PDCCH S_{DCCB}, RS signal S_{DRSB} and PDSCH S_{DSCB} as input, multiplexes these signals to generate a downlink multiplexed signal S_{MUXB}, and outputs it; the transmitter **115** receives the downlink multiplexed signal S_{MUXB} as input, generates a transmit signal S_{TXB}, and outputs it (Step S**10**).

The receiver **201** in the mobile station **200** receives a signal from the base station **100**, establishes downlink synchronization using a guard interval, and outputs a mobile station receive signal S_{RXU} (Step S**11**).

The downlink RS (Reference Signal) separator **202** receives the mobile station receive signal S_{RXU} as input, and separates therefrom a downlink RS signal S_{DRSU} in which the downlink RS signals are multiplexed; the downlink CQI measurement section **203** receives the downlink RS signal S_{DRSU} as input, calculates CQI on an RB-by-RB basis, and outputs it as downlink CQI information S_{DCQB} (Step S**12**).

The downlink control signal separator **206** receives the mobile station receive signal S_{RXU} as input, and separates therefrom PDCCH S_{DCCU} in which downlink control signals from a plurality of mobile stations are multiplexed; the downlink control signal demodulator **207** demodulates the PDCCH S_{DCCU} to reproduce a downlink control signal, separates therefrom a result of reproduction in which mobile station identification information corresponding to the mobile station itself is multiplexed, and outputs it as a downlink control reproduced signal S_{DCMU} (Step S**13**).

The downlink scheduling information extracting section **208** receives the downlink control reproduced signal S_{DCMU} as input, extracts therefrom downlink RB allocation decision information S_{DSCU} corresponding to downlink resource allocation information, and outputs it (Step S**14**).

The uplink scheduling information extracting section **210** extracts, from the downlink control reproduced signal S_{DCMU}, UL Scheduling Grant, which represents information on allocated uplink RBs, and checks the value of the allocation resolution (Step S**15**).

Next, it discriminates a tree structure in the Tree-Based method from the value of the allocation resolution, identifies RBs indicated by the uplink RB allocation information in this tree structure, and outputs it as uplink RB allocation decision information S_{USCU} (Step S**16**).

The uplink control signal generator **211** receives the uplink RB allocation decision information S_{USCU} and downlink CQI information S_{DCQB} as input, generates Physical Uplink Control Channel (PUCCH) S_{UCCU} in which the downlink CQI information S_{DCQB} is multiplexed with a predetermined resource for a control signal indicated by the uplink RB allocation decision information S_{USCU}, and outputs it (Step S**17**).

The uplink RS signal generator **212** receives the uplink RB allocation decision information S_{USCU} as input, generates an uplink RS transmit signal S_{URSU} using a predetermined resource for RS in the uplink RB allocation decision information S_{USCU}, and outputs it (Step S**18**).

The uplink data signal generator **213** receives the uplink RB allocation decision information S_{USCU} as input, generates Physical Uplink Shared Channel (PUSCH) S_{UDCU} using a predetermined resource for a data signal in the uplink RB allocation decision information S_{USCU}, and outputs it (Step S**19**).

The multiplexer **214** receives the PUCCH S_{UCCU}, uplink RS transmit signal S_{URSU}, PUSCH S_{UDCU} and downlink control signal decision signal S_{DAKU} as input, and multiplexes these signals to generate a mobile station multiplexed signal S_{MUXU}; the transmitter **215** transmits the mobile station transmit signal S_{MUXU} to the base station **100** (Step S**20**).

While a mode in which the number of frequency blocks is determined from a condition of mobile station's channel quality (the CQI measured by a sounding reference signal) is addressed in the embodiment described above, it may be contemplated that the present embodiment uses information about a communication environment, such as, for example, the cell size, system bandwidth, coverage of a base station, bandwidth of an uplink sounding reference signal, bandwidth used in uplink data transmission, number of levels in multilevel modulation and code rate used in uplink data transmission, transmittable/receivable bandwidth of a mobile station (sometimes referred to as UE capability), and type of uplink transmission data (VoIP, HTTP, FTP etc.), or information affecting the communication environment, such as the billing scheme in which a user signs on, power headroom (which is a difference between the maximum transmit power of a mobile station and an actual transmit power of the mobile station), and target SINR in uplink power control. Moreover, since the cell size is determined by information affecting the communication environment, such as the location of a base station, distance between base stations, and interference power, these information may be used to select a number of frequency blocks.

Furthermore, while the description has been made in the present embodiment using a configuration in which a number of frequency blocks is determined from a condition of mobile station's channel quality and an allocation resolution is set in accordance with the frequency blocks, the configuration may be one such that the allocation resolution is set in accordance with a condition of mobile station's channel quality, the information on a communication environment described above, or the information that affect a communication environment described above. Moreover, in the present embodiment, the number of frequency blocks is described as being notified through Physical Downlink Control Channel (PDCCH), it is additionally notified with a control signal in a higher layer mapped over PBCH (Physical Broadcast Channel), PDSCH (Physical Downlink Shared Channel), which is also referred to as Dynamic BCH, or the like. In this case, a number of frequency blocks S_{UDFB} is input to a PBCH generator or PDSCH generator (both not shown) provided in the downlink control signal generator **111** in the base station, and is notified to a mobile station through the PBCH or PDSCH. Furthermore, since information on the uplink and downlink control signals varies from frame to frame in about 1 msec, there arises a problem that processing in a terminal becomes complicated in a case that the allocation resolution is modified with such a variation. Thus, additional limitation may be posed to modify the allocation resolution in a cycle of a plurality of frames.

Moreover, while the description has been made using a mode in which the uplink scheduler **104** allocates RBs with resource blocks in a number equal to the determined allocation resolution and with the determined number of frequency blocks in the present embodiment, a mode may be contemplated in which RBs are allocated with resource blocks in a number equal to the determined allocation resolution and within the determined number of frequency blocks.

The system band has been described as having 10 RBs for simplifying the explanation above; now an effect of reducing the number of bits in an actual LTE system having a system band of 20 MHz will be described. Similarly to the LTE downlink in which a plurality of frequency blocks can be allocated, the number of bits required for one frequency block in making notification using the Tree-Based method in a system band of 20 MHz (the number of RBs=100) is $\log_2 100(100+1)/2=13$ bits. Thus, a correspondence table of the number of frequency blocks and allocation resolution as shown FIG. **3** is established so as not to exceed 37 bits, which is an upper limit of the scheduling information stipulated for actual LTE downlink. FIG. **11** shows a number of bits required to notify RB patterns for frequency blocks in a number equal to the number of frequency blocks using the Tree-Based method, for numbers of frequency blocks of 1-4, respectively. Thus, in accordance with the present invention, the correspondence between the number of frequency blocks and allocation resolution can be established in accordance with an environment, and therefore, it is possible to hold the number of signaling bits for scheduling information down to 35 bits, including notification of an allocation resolution (two bits), which is less than the stipulated upper limit, 37 bits.

As described above, the number of frequency blocks for a mobile station with good channel quality is increased, while that for a mobile station with poor channel quality is decreased, and an allocation resolution is determined accordingly. This is because a mobile station with good channel quality performs transmission with a lower electric power density, and hence, with a broader band, and since the channel quality is good as a whole, it will not be degraded even when the allocation resolution is increased with the number of frequency blocks. On the other hand, a mobile station with poor channel quality performs transmission with a higher electric power density, and hence, with a narrower band, and since the channel quality is poor as a whole, the allocation resolution must be reduced with the number of frequency blocks in order to accurately select better resources among all. Thus, by correlating the allocation resolution, the number of frequency blocks and the channel quality of a mobile station, degradation of the reception property due to setting of an allocation resolution may be reduced.

<Second Embodiment>

The embodiment described above addresses a case in which a base station notifies a value of the allocation resolution borne on UL Scheduling Grant to a mobile station. The following embodiment will address a case in which a base station sets an allocation resolution correlated with a number of frequency blocks in one-to-one correspondence, and a mobile station recognizes the allocation resolution from the notified number of frequency blocks. It should be noted that components similar to those in the foregoing embodiment are designated by similar reference numerals and detailed description thereof will be omitted.

The uplink scheduler **104** in the base station **100** makes uplink scheduling for each mobile station. The uplink scheduler **104** determines a number of frequency blocks for resources to be allocated based on uplink CQI information S_{UCQB}. RBs are allocated with an allocation resolution set in accordance with the determined number of frequency blocks and with the determined number of frequency blocks. The scheduling information representing positions of the allocated RBs is output as UL Scheduling Grant S_{USCB}, and the number of frequency blocks is output as S_{UDFB}.

The downlink control signal generator **111** in the base station **100** receives the UL Scheduling Grant S_{USCB}, DL Scheduling Grant S_{DSCB}, mobile station identification information S_{UIDB}, and frequency block signal S_{UDFB} as input, multiplexes these signals to generate a downlink control signal as PDCCH (Physical Downlink Control Channel) S_{DCCB}, and outputs it. It should be noted that the number of frequency blocks is notified not only through the Physical Downlink Control Channel (PDCCH) but also through PBCH, PDSCH, etc.

The downlink control signal demodulator **207** in the mobile station **200** receives the PDCCH S_{DCCU} as input, demodulates the PDCCH S_{DCCU} to reproduce a downlink control signal, separates therefrom a result of reproduction in which mobile station identification information corresponding to the mobile station itself is multiplexed, and outputs it as a downlink control reproduced signal S_{DCMU}.

The uplink scheduling information extracting section **210** in the mobile station **200** extracts, from the downlink control reproduced signal S_{DCMU}, UL Scheduling Grant, which represents information on allocated uplink RBs, and frequency block signal S_{UDFU}. Next, it recognizes an allocation resolution correlated with the number of frequency blocks in a one-to-one correspondence from the frequency block signal S_{UDFU} and the correspondence table kept by the mobile station itself. It then discriminates a tree structure in the Tree-Based method from the allocation resolution, identifies RBs indicated by the uplink RB allocation information in this tree structure, and outputs it as uplink RB allocation decision information S_{USCU}.

Subsequently, an operation of the present embodiment will be described with reference to a flow chart in FIG. **12**.

The receiver **101** in the base station **100** receives a signal from the mobile station **200**, establishes uplink synchronization using a guard interval, and outputs a base station receive signal S_{RXB} (Step S**1**).

The uplink RS (Reference Signal) separator **102** separates from the output base station receive signal S_{RXB} an uplink RS signal S_{URSB} in which uplink RS signals from a plurality of mobile stations are multiplexed, and outputs it (Step S**2**).

From the uplink RS signals S_{URSB} for a plurality of mobile stations, the uplink CQI measurement section **103** calculates CQI (Channel Quality Indicator) for each mobile station on an RB-by-RB basis, and outputs it as uplink CQI information S_{UCQB} (Step S**3**).

The uplink scheduler **104** determines a number of frequency blocks for resources to be allocated to each mobile station based on the uplink CQI information S_{UCQB} for each mobile station (Step S**4**).

An allocation resolution correlated with the determined number of frequency blocks is determined using the correspondence table as shown in FIG. **3** kept in the equipment itself, whereby a structure in the Tree-Based method is determined, and the number of bits for UL Scheduling Grant is set as a number of bits in accordance with the determined structure in the Tree-Based method (Step S**5**).

RBs are allocated with resource blocks in a number equal to the determined allocation resolution and with the determined number of frequency blocks (Step S**6**).

Next, the uplink scheduler **104** outputs scheduling information representing positions of the allocated RBs in a Tree-Based form in a specified number of bits as UL Scheduling Grant S_{USCB}, and outputs the number of frequency blocks as S_{UDFB} (Step S**7-1**).

The downlink control signal generator **111** is supplied as input with the UL Scheduling Grant S_{USCB}, DL Scheduling Grant S_{DSCB}, mobile station identification information S_{UIDB} and frequency block signal S_{UDFB}, multiplexes these input signals to generate a downlink control signal as PDCCH (Physical Downlink Control Channel) S_{DCCB}, and outputs it (Step S**8**).

The downlink RS signal generator **112** generates a downlink RS signal as a downlink RS signal S_{DRSB}, and outputs it; the downlink data signal generator **113** receives the DL Scheduling Grant S_{DSCB} as input, multiplexes downlink data signals from a plurality of mobile stations together in accordance with an RB pattern indicated by the DL Scheduling Grant S_{DSCB}, generates Physical Downlink Shared Channel (PDSCH) S_{DDCB}, and outputs it (Step S**9**).

The multiplexer **114** receives the PDCCH S_{DSCB}, RS signal S_{DRSB} and PDSCH S_{DDCB} as input, multiplexes these signals to generate a downlink multiplexed signal S_{MUXB}, and outputs it; the downlink multiplexed signal S_{MUXB} is transmitted by the transmitter **115** (Step S**10**).

The receiver **201** in the mobile station **200** receives a signal from the base station **100**, establishes downlink synchronization using a guard interval, and outputs a mobile station receive signal S_{RXU} (Step S**11**).

The downlink RS (Reference Signal) separator **202** receives the mobile station receive signal S_{RXU} as input, and separates therefrom a downlink RS signal S_{DRSU} in which the downlink RS signals are multiplexed; the downlink CQI measurement section **203** calculates CQI from the downlink RS signal S_{DRSU} on an RB-by-RB basis, and outputs it as downlink CQI information S_{DCQB} (Step S**12**).

The downlink control signal separator **206** receives the mobile station receive signal S_{RXU} as input, separates therefrom PDCCH S_{DCCU} in which downlink control signals from a plurality of mobile stations are multiplexed, and outputs it; the downlink control signal demodulator **207** demodulates the PDCCH S_{DCCU} to reproduce a downlink control signal, separates therefrom a result of reproduction in which mobile station identification information corresponding to the mobile station itself is multiplexed, and outputs it as a downlink control reproduced signal S_{DCMU} (Step S**13**).

The downlink scheduling information extracting section **208** receives the downlink control reproduced signal S_{DCMU} as input, extracts therefrom downlink RB allocation decision information S_{DSCU} corresponding to downlink resource allocation information, and outputs it (Step S**14**).

The uplink scheduling information extracting section **210** extracts, from the downlink control reproduced signal S_{DCMU}, UL Scheduling Grant, which represents information on allocated uplink RBs, and frequency block signal S_{UDFU}, and recognizes the value of the allocation resolution based on the number of frequency blocks represented by the frequency block signal S_{UDFU} (Step S**15**-**1**).

Next, it discriminates a tree structure in the Tree-Based method from the value of the allocation resolution, identifies RBs indicated by the uplink RB allocation information in this tree structure, and outputs it as uplink RB allocation decision information S_{USCU} (Step S**16**).

The uplink control signal generator **211** receives the uplink RB allocation decision information S_{USCU} and downlink CQI information S_{DCQB} as input, generates Physical Uplink Control Channel (PUCCH) S_{UCCU} in which the downlink CQI information S_{DCQB} is multiplexed with a predetermined resource for a control signal indicated by the uplink RB allocation decision information S_{USCU}, and outputs it (Step S**17**).

The uplink RS signal generator **212** receives the uplink RB allocation decision information S_{USCU} as input, generates an uplink RS transmit signal S_{URSU} using a predetermined resource for RS in the uplink RB allocation decision information S_{USCU}, and outputs it (Step S**18**).

The uplink data signal generator **213** receives the uplink RB allocation decision information S_{USCU} as input, generates Physical Uplink Shared Channel (PUSCH) S_{UDCU} using a predetermined resource for a data signal in the uplink RB allocation decision information S_{USCU}, and outputs it (Step S**19**).

The multiplexer **214** receives the PUCCH S_{UCCU}, uplink RS transmit signal S_{URSU}, PUSCH S_{USCU} and downlink control signal decision signal S_{DAKU} as input, and multiplexes these signals to generate a mobile station multiplexed signal S_{MUXU}; the transmitter **215** transmits the mobile station transmit signal S_{MUXU} to the base station **100** (Step S**20**).

Other methods include one involving correlating the allocation resolution with downlink CQI information and/or with localization information for a mobile station in the uplink control signal that the mobile station notifies to the base station, with MCS (Modulation and Coding Scheme) and/or with power control target value in the downlink control signal that the base station notifies to the mobile station, or the like in a one-to-one correspondence. By correlating information in these control signals with the allocation resolution, the allocation resolution can be shared between the base station and mobile station. Moreover, a tree structure in the Tree-Based method may be discriminated from the number of frequency blocks notified by the base station.

According to the present embodiment, since the value of the allocation resolution is not notified, the number of signaling bits can be reduced by those for notifying the value of the allocation resolution (two bits).

<Third Embodiment>

The embodiments described above have addressed a case in which an allocation resolution is determined in accordance with the number of frequency blocks determined by the uplink scheduler **104**. The following embodiment will address a case in which an allocation resolution is determined in accordance with a maximum number of frequency blocks determined by a maximum-number-of-frequency-blocks determining section **105** in accordance with uplink CQI. It should be noted that components similar to those in the foregoing embodiments are designated by similar reference numerals and detailed description thereof will be omitted.

FIG. **13** shows a block diagram of a base station **100** in the present embodiment. This is different from the foregoing embodiments in that a maximum-number-of-frequency-blocks determining section **105** is incorporated.

The maximum-number-of-frequency-blocks determining section **105** receives uplink CQI information S_{UCQB} as input, determines a maximum number of frequency blocks in resource blocks to be allocated to mobile stations, generates a maximum-frequency-block signal S_{UDFB} for each mobile station, and outputs it.

For example, in MC-FDMA in which output of a transmitter DFT (Discrete Fourier Transform) in DFT-spread-OFDM (Discrete Fourier Transform-spread-Orthogonal Frequency Division Multiplexing) is allocated to at least one or more frequency blocks, PAPR becomes higher for a larger number of frequency blocks, and therefore, the PAPR increase in mobile stations at the periphery of a cell becomes problematic unless a limit is imposed on the number of frequency blocks. Thus, based on system information for a base station or mobile station or the like, a maximum allowable number of frequency blocks may be sometimes set for each base station (cell), for each mobile station, or for each mobile station group. Thus, the maximum-number-of-frequency-blocks determining section **105** sets a larger maximum number of frequency blocks in a situation that a greater multi-user diversity effect is desirable (in a situation that the system band is broad, or CQI is good), or sets a smaller maximum number of frequency blocks in a situation that an increase in overhead is desired to be held down (in a situation that the system band is narrow, or CQI is poor).

The uplink scheduler **104** makes uplink scheduling for each mobile station. The uplink scheduler **104** receives uplink CQI information S_{UCQB} and maximum-frequency-block signal S_{UDFB} as input, limits the maximum number of frequency blocks for resource blocks to be allocated within a number represented by the maximum-frequency-block signal S_{UDFB}, and makes RB allocation with an allocation resolution corresponding to the maximum-frequency-block signal S_{UDFB}. Then, it outputs scheduling information, which is scheduling information representing the positions of the allocated RBs, and maximum number of frequency blocks as UL Scheduling Grant S_{USCB}.

Subsequently, a description will be made on the mobile station **200**. FIG. **14** shows a block diagram of a mobile station **200** in the present embodiment. This is different from the foregoing embodiments in that a maximum-number-of-frequency-blocks extracting section **209** is incorporated.

The maximum-number-of-frequency-blocks extracting section **209** receives downlink control reproduced signal S_{DCMU} as input, separates therefrom a received maximum-frequency-block signal S_{UDFU} for the mobile station itself, and outputs it.

The uplink scheduling information extracting section **210** extracts, from the downlink control reproduced signal S_{DCMU}, UL Scheduling Grant that represents information on allocated uplink RBs. Next, it discriminates an allocation resolution correlated with the received maximum-frequency-block signal S_{UDFU} in a one-to-one correspondence from the received maximum-frequency-block signal S_{UDFU} output from the maximum-number-of-frequency-blocks extracting section **209**. It discriminates a tree structure in the Tree-Based method from the allocation resolution, identifies RBs indicated by the uplink RB allocation information in this tree structure, and outputs it as uplink RB allocation decision information S_{USCU}.

Subsequently, an operation of the present embodiment will be described with reference to a flow chart in FIG. **15**.

The receiver **101** in the base station **100** receives a signal from the mobile station **200**, establishes uplink synchronization using a guard interval, and outputs a base station receive signal S_{RXB} (Step S**1**).

The uplink RS (Reference Signal) separator **102** separates from the output base station receive signal S_{RXB} an uplink RS signal S_{URSB} in which uplink RS signals from a plurality of mobile stations are multiplexed, and outputs it (Step S**2**).

From the uplink RS signals S_{URSB} for a plurality of mobile stations, the uplink CQI measurement section **103** calculates CQI (Channel Quality Indicator) for each mobile station on an RB-by-RB basis, and outputs it as uplink CQI information S_{UCQB} (Step S**3**).

The maximum-number-of-frequency-blocks determining section **105** determines a maximum number of frequency blocks in resource blocks to be allocated to each mobile station based on the uplink CQI information S_{UCQB}, generates a maximum-frequency-block signal S_{UDFB} for each mobile station, and outputs it (Step S**4-1**).

The uplink scheduler **104** determines an allocation resolution correlated with the maximum number of frequency blocks represented in the maximum-frequency-block signal S_{UDFB} using the correspondence table as shown in FIG. **3** kept in the equipment itself, whereby it also determines a structure in the Tree-Based method, and sets the number of bits for UL Scheduling Grant as a number of bits in accordance with the determined structure in the Tree-Based method (Step S**5**).

RBs are allocated with resource blocks in a number equal to the determined allocation resolution and within the determined number of frequency blocks (Step S**6**).

Next, the uplink scheduler **104** outputs scheduling information representing positions of the allocated RBs, and the maximum number of frequency blocks in a specified number of bits as UL Scheduling Grant S_{USCB} (Step S**7-2**).

The downlink control signal generator **111** is supplied as input with the UL Scheduling Grant S_{USCB}, DL Scheduling Grant S_{DSCB}, mobile station identification information S_{UIDB} and received maximum-frequency-block signal S_{UDFB}, multiplexes these input signals to generate a downlink control signal as PDCCH (Physical Downlink Control Channel) S_{DCCB}, and outputs it (Step S**8**).

The downlink RS signal generator **112** generates a downlink RS signal as a downlink RS signal S_{DRSB}, and outputs it; the downlink data signal generator **113** receives the DL Scheduling Grant S_{DSCB} as input, multiplexes downlink data signals from a plurality of mobile stations together in accordance with an RB pattern indicated by the DL Scheduling Grant S_{DSCB}, generates Physical Downlink Shared Channel (PDSCH) S_{DDCB}, and outputs it (Step S**9**).

The multiplexer **114** receives the PDCCH S_{DCCB}, RS signal S_{DRSB} and PDSCH S_{DDCB} as input, and multiplexes these signals to generate a downlink multiplexed signal S_{MUXB}; the transmitter **115** generates a transmit signal S_{TXB} from the downlink multiplexed signal S_{MUXB}, and outputs it (Step S**10**).

The receiver **201** in the mobile station **200** receives a signal from the base station **100**, establishes downlink synchronization using a guard interval, and outputs a mobile station receive signal S_{RXU} (Step S**11**).

The downlink RS (Reference Signal) separator **202** receives the mobile station receive signal S_{RXU} as input, and separates therefrom a downlink RS signal S_{DRSU} in which the downlink RS signals are multiplexed; the downlink CQI measurement section **203** receives the downlink RS signal S_{DRSU} as input, calculates CQI on an RB-by-RB basis, and outputs it as downlink CQI information S_{DCQB} (Step S**12**).

The downlink control signal separator **206** receives the mobile station receive signal S_{RXU} as input, and separates therefrom PDCCH S_{DCCU} in which downlink control signals from a plurality of mobile stations are multiplexed; the downlink control signal demodulator **207** demodulates the PDCCH S_{DCCU} to reproduce a downlink control signal, separates therefrom a result of reproduction in which mobile station identification information corresponding to the mobile station itself is multiplexed, and outputs it as a downlink control reproduced signal S_{DCMU} (Step S**13**).

The downlink scheduling information extracting section **208** receives the downlink control reproduced signal S_{DCMU} as input, extracts therefrom downlink RB allocation decision information S_{DSCU} corresponding to downlink resource allocation information, and outputs it (Step S**14**).

The maximum-number-of-frequency-blocks extracting section **209** receives the downlink control reproduced signal S_{DCMU} as input, separates therefrom the received maximum-frequency-block signal S_{UDFU} for the mobile station itself, and outputs it; the uplink scheduling information extracting section **210** checks a value of the allocation resolution from the received maximum-frequency-block signal S_{UDFU} (Step S**15-2**).

Next, it discriminates a tree structure in the Tree-Based method from the value of the allocation resolution, identifies RBs indicated by the uplink RB allocation information in this tree structure, and outputs it as uplink RB allocation decision information S_{USCU} (Step S**16**).

The uplink control signal generator **211** receives the uplink RB allocation decision information S_{USCU} and downlink CQI information S_{DCQB} as input, generates Physical Uplink Control Channel (PUCCH) S_{UCCU} in which the downlink CQI information S_{DCQB} is multiplexed with a predetermined resource for a control signal indicated by the uplink RB allocation decision information S_{USCU}, and outputs it (Step S**17**).

The uplink RS signal generator **212** receives the uplink RB allocation decision information S_{USCU} as input, generates an uplink RS transmit signal S_{URSU} using a predetermined resource for RS in the uplink RB allocation decision information S_{USCU}, and outputs it (Step S**18**).

The uplink data signal generator **213** receives the uplink RB allocation decision information S_{USCU} as input, generates Physical Uplink Shared Channel (PUSCH) S_{UDCU} using a predetermined resource for a data signal in the uplink RB allocation decision information S_{USCU}, and outputs it (Step S**19**).

The multiplexer **214** receives the PUCCH S_{UCCU}, uplink RS transmit signal S_{URSU}, PUSCH S_{UDCU} and downlink control signal decision signal S_{DAKU} as input, and multiplexes these signals to generate a mobile station multiplexed signal S_{MUXU}; the transmitter **215** transmits the mobile station transmit signal S_{MUXU} to the base station **100** (Step S**20**).

While a case in which the maximum number of frequency blocks is incorporated in UL Scheduling Grant has been addressed in the description above, the maximum number of frequency blocks is notified by a signal mapped to Physical Downlink Shared Channel (PDSCH), which is generally referred to as Physical Broadcast Channel (PBCH) or Dynamic Broadcast Channel (DBCH), in a case that the maximum number of frequency blocks is determined as a cell-specific value. Moreover, for a UE-specific case, it is notified by information on Higher layer signaling mapped to

PDSCH. In such a case, there is no need to incorporate the maximum number of frequency blocks into UL Scheduling Grant.

Moreover, while a case in which the maximum number of frequency blocks is incorporated in UL Scheduling Grant has been addressed in the description above, information on the allocation resolution, in place of the maximum number of frequency blocks, may be incorporated. In this case, the uplink scheduling information extracting section **210** is configured to extract UL Scheduling Grant from the downlink control reproduced signal S_{DCMU} to discriminate the allocation resolution.

A case in which the maximum frequency block is determined in accordance with uplink CQI has been addressed in the description above; now another method for determining a maximum frequency block will be described below.

First, a configuration will be described in which the maximum-number-of-frequency-blocks determining section determines the maximum number of frequency blocks according to the location of the mobile station and base station.

FIG. **16** shows a block diagram of a base station **100** for determining the maximum number of frequency blocks according to the location of the mobile station and base station.

In the base station **100**, the uplink control signal demodulator **109** demodulates PUCCH S_{UCCB}, and outputs a downlink CQI measurement signal S_{UCQB}, which is a result of measurement of downlink CQI transmitted by a plurality of mobile stations, and received mobile station localization information S_{ULCB} representing the location of the mobile station.

A maximum-number-of-frequency-blocks determining section **105-1** receives the received mobile station localization information S_{ULCB} as input, determines a maximum number of frequency blocks in frequency resources to be allocated to each mobile station from the location of the mobile station represented by the received mobile station localization information S_{ULCB}, generates a maximum-frequency-block signal S_{UDFB} for each mobile station, and outputs it. In particular, the maximum number of frequency blocks is determined and generated to have a smaller value for a user located farther away from the base station.

FIG. **17** shows a block diagram of a mobile station **200** when a maximum number of frequency blocks is determined in accordance with the location of the mobile station and base station.

In the mobile station **200**, a localizing section **416** has a function of locating the mobile station using a signal from a GPS signal satellite, and it receives a signal from the GPS satellite, locates the mobile station **200**, generates mobile station localization information S_{ULCU}, and outputs it.

An uplink control signal generator **211-1** receives the uplink RB allocation decision information S_{USCU}, downlink CQI information S_{DCQB}, and mobile station localization information S_{ULCU} as input, generates PUCCH S_{UCCU} using a predetermined resource for a control signal in resources indicated by the uplink RB allocation decision information S_{USCU} along with the downlink CQI information S_{DCQB} and mobile station localization information S_{ULCU}, and outputs it.

By the aforementioned configuration, RBs are allocated with a lower allocation resolution to a mobile station having a smaller maximum number of frequency blocks, and with a higher allocation resolution to a mobile station having a larger maximum number of frequency blocks.

Subsequently, a case will be described in which the maximum-number-of-frequency-blocks determining section determines a maximum number of frequency blocks in accordance with the power headroom, which represents an increasable transmit power in a mobile station.

FIG. **18** shows a block diagram of a base station **100** in which the maximum number of frequency blocks is determined in accordance with the power headroom, which represents an increasable transmit power in a mobile station.

In the base station **100**, an uplink transmit power determining section **517** receives the uplink CQI information S_{UCQB} as input, calculates a transmit power value for the mobile station required to satisfy a required receive power, generates uplink transmit power setting information S_{UPWB}, and outputs it.

The uplink control signal demodulator **109** demodulates the uplink control signal S_{UCCB}, and outputs a downlink CQI measurement signal S_{DCQB}, which is a result of measurement of downlink CQI transmitted by a plurality of mobile stations, and mobile station power headroom received information S_{UHRB}.

A maximum-number-of-frequency-blocks determining section **105-2** receives the power headroom received information S_{UHRB} as input, determines a maximum number of frequency blocks in frequency resources to be allocated to each mobile station based on the power headroom received information S_{UHRB}, generates a maximum-frequency-block signal S_{UDFB} for the mobile station, and outputs it. In particular, for example, setting the initial value of the maximum number of frequency blocks as one, and in a case that the value represented by the power headroom received information S_{UHRB} exceeds a threshold electric power P_{DFUP} (P_{DFUP} is a positive real number), the value of the maximum number of frequency blocks is incremented by one. In a case that the value represented by the power headroom received information S_{UHRB} is zero and the maximum number of frequency blocks is two or more, the value of the maximum number of frequency blocks is decremented by one. That is, in a case that the transmit power has an extra capacity, the maximum number of frequency blocks is increased to increase the number of allocatable frequency blocks, and enhance the gain in frequency domain channel dependent scheduling. In a case that the transmit power has no extra capacity and is power-limited, the maximum number of frequency blocks is reduced to transmit signals with higher electric power density.

The downlink control signal generator **511** receives the mobile station identification information S_{UIDB}, UL Scheduling Grant S_{USCB}, DL Scheduling Grant S_{DSCB}, maximum-frequency-block signal S_{UDFB} and uplink transmit power setting information S_{UPWB} as input, generates a downlink control signal in which these signals are multiplexed as PDCCH S_{DCCB}, and outputs it.

FIG. **19** shows a block diagram of a mobile station **200** in which the maximum number of frequency blocks is determined in accordance with the power headroom, which represents an increasable transmit power in the mobile station.

In the mobile station **200**, an uplink transmit power information extracting section **616** extracts, from the downlink control reproduced signal S_{DCMU}, received uplink transmit power setting value information S_{UPWU} that represents the uplink transmit power value in the mobile station and is notified by the base station, and outputs it.

A power headroom calculating section **617** receives the received uplink transmit power setting value information S_{UPWU} as input, subtracts the received uplink transmit power setting value information S_{UPWU} from the maximum transmit power value transmittable by the mobile station, and outputs the resulting value as mobile station power headroom information S_{UHRU}. The mobile station power headroom information S_{UHRU} represents the remaining electric power with which the mobile station can perform additional transmission after transmission with an electric power represented by the received uplink transmit power setting value information S_{UPWU}.

An uplink control signal generator **211-2** receives the uplink RB allocation decision information S_{USCU}, downlink CQI information S_{DCQB}, and mobile station power headroom information S_{UHRU} as input, generates PUCCH S_{UCCU} using a predetermined resource for a control signal in resources represented by the uplink RB allocation decision information S_{USCU} along with the downlink CQI information S_{UCQB} and mobile station power headroom information S_{UHRU}, and outputs it.

By the aforementioned configuration, RBs are allocated with a lower allocation resolution to a mobile station having a smaller maximum number of frequency blocks, and with a higher allocation resolution to a mobile station having a larger maximum number of frequency blocks.

As described above, in accordance with the present embodiment, in the Tree-Based method, RBs are allocated with a lower allocation resolution to a mobile station having a smaller maximum number of frequency blocks, and with a higher allocation resolution to a mobile station having a larger maximum number of frequency blocks, so that an increase in the amount of signaling due to an increase of the number of frequency blocks can be prevented.

<Fourth Embodiment>

The first and second embodiments have addressed a case in which an allocation resolution is determined in accordance with the number of frequency blocks determined by the scheduler, and the third embodiment has addressed a case in which an allocation resolution is determined in accordance with the maximum number of frequency blocks determined by the maximum-number-of-frequency-blocks determining section. The following embodiment is characterized in checking a sequence of resource blocks allocated in accordance with any one of the embodiments described above, and in a case that transmission may be made with a number of bits smaller than that for determining information representing the allocated resource blocks, performing transmission with a smaller number of bits. It should be noted that components similar to those in the foregoing embodiment are designated by similar reference numerals and detailed description thereof will be omitted.

For example, assuming that the number of frequency blocks or maximum number of frequency blocks is one, the allocation resolution is set as one with reference to the correspondence table in FIG. **3**. Now assume that as a result of an act of the scheduler allocating resource blocks with a number of frequency blocks of one and an allocation resolution of one, resource blocks at positions numbered “2,” “3,” “4” and “5” are allocated as shown in FIG. **20**. In this case, according to the embodiments described above, a value “32” within 1-55 (six bits) is used to make denotation in the Tree-Based method.

However, in actuality, as shown in FIG. **21**, it may be denoted in the Tree-Based method using a value “6” within 1-15 that can be denoted by four bits. In other words, resource block allocation may be denoted in the Tree-Based method with a smaller number of bits.

The uplink scheduler **104** in the present embodiment checks a sequence of allocated resource blocks, and in a case that transmission may be made with a number of bits smaller than that for determining information representing the allocated resource blocks, updates the value of the allocation resolution determined once and outputs UL Scheduling Grant in a number of bits in accordance with the updated value of the allocation resolution.

Subsequently, an operation of the present embodiment will be described with reference to a flow chart in FIG. **22**. While the following description will be made with reference to the first embodiment, it may be based on the third embodiment.

The receiver **101** in the base station **100** receives a signal from the mobile station **200**, establishes uplink synchronization using a guard interval, and outputs a base station receive signal S_{RXB}, (Step S**1**).

The uplink RS (Reference Signal) separator **102** separates from the output base station receive signal S_{RXB} an uplink RS signal S_{URSB} in which uplink RS signals from a plurality of mobile stations are multiplexed, and outputs it (Step S**2**).

From the uplink RS signals S_{URSB} for a plurality of mobile stations, the uplink CQI measurement section **103** calculates CQI (Channel Quality Indicator) for each mobile station on an RB-by-RB basis, and outputs it as uplink CQI information S_{UCQB} (Step S**3**).

The uplink scheduler **104** determines a number of frequency blocks for resources to be allocated to each mobile station based on the uplink CQI information S_{UCQB} for each mobile station (Step S**4**). An allocation resolution correlated with the determined number of frequency blocks is determined using the correspondence table as shown in FIG. **3** kept in the equipment itself (Step S**5**).

RBs are allocated with resource blocks in a number equal to the determined allocation resolution and with the determined number of frequency blocks (Step S**6**).

From a sequence of the allocated RBs, decision is made as to whether transmission may be made with a number of bits smaller than that for determining information representing the allocated resource blocks (Step S**21**). In a case that transmission may be made with a number of bits smaller than that for determining information representing the allocated resource blocks, the value of the allocation resolution determined once is updated, and the number of bits is set to that in accordance with the allocation resolution from the updated number of bits for UL Scheduling Grant (Step S**22**). On the other hand, in a case that transmission cannot be made with a number of bits smaller than that for determining information representing the allocated resource blocks, the flow goes to Step S**7-1**.

Next, the uplink scheduler **104** outputs scheduling information representing positions of the allocated RBs and value of the allocation resolution in a specified number of bits as UL Scheduling Grant S_{USCB}, and outputs the number of frequency blocks as S_{UDFB} (Step S**7-1**).

The downlink control signal generator **111** is supplied as input with the UL Scheduling Grant S_{USCB}, DL Scheduling Grant S_{DSCB}, mobile station identification information S_{UIDB} and frequency block signal S_{UDFB}, multiplexes these input signals to generate a downlink control signal as PDCCH (Physical Downlink Control Channel) S_{DCCB}, and outputs it (Step S**8**).

The downlink RS signal generator **112** generates a downlink RS signal as a downlink RS signal S_{DRSB}; the downlink data signal generator **113** multiplexes downlink data signals from a plurality of mobile stations together in accordance with an RB pattern indicated by the DL Scheduling Grant S_{DSCB}, generates Physical Downlink Shared Channel (PDSCH) S_{DDCB}, and outputs it (Step S**9**).

The multiplexer **114** receives the PDCCH S_{DCCB}, RS signal S_{DRSB} and PDSCH S_{DDCB} as input, and multiplexes these signals to generate a downlink multiplexed signal S_{MUXB}; the transmitter **115** generates a transmit signal S_{TXB} from the downlink multiplexed signal S_{MUXB}, and transmits it (Step S**10**).

The receiver **201** in the mobile station **200** receives a signal from the base station **100**, establishes downlink synchronization using a guard interval, and outputs a mobile station receive signal S_{RXU} (Step S**11**).

The downlink RS (Reference Signal) separator **202** receives the mobile station receive signal S_{RXU} as input, separates therefrom a downlink RS signal S_{DRSU} in which the downlink RS signals are multiplexed, and outputs it; the downlink CQI measurement section **203** calculates CQI from the downlink RS signal S_{DRSU} on an RB-by-RB basis, and outputs it as downlink CQI information S_{DCQB} (Step S**12**).

The downlink control signal separator **206** receives the mobile station receive signal S_{RXU} as input, and separates therefrom PDCCH S_{DCCU} in which downlink control signals from a plurality of mobile stations are multiplexed; the downlink control signal demodulator **207** demodulates the PDCCH S_{DCCU} to reproduce a downlink control signal, separates therefrom a result of reproduction in which mobile station identification information corresponding to the mobile station itself is multiplexed, and outputs it as a downlink control reproduced signal S_{DCMU} (Step S**13**).

The downlink scheduling information extracting section **208** receives the downlink control reproduced signal S_{DCMU} as input, extracts therefrom downlink RB allocation decision information S_{DSCU} corresponding to downlink resource allocation information, and outputs it (Step S**14**).

The uplink scheduling information extracting section **210** extracts, from the downlink control reproduced signal S_{DCMU}, UL Scheduling Grant, which represents information on allocated uplink RBs, and checks the value of the allocation resolution (Step S**15**).

Next, it discriminates a tree structure in the Tree-Based method from the value of the allocation resolution, identifies RBs indicated by the uplink RB allocation information in this tree structure, and outputs it as uplink RB allocation decision information S_{USCU} (Step S**16**).

The uplink control signal generator **211** receives the uplink RB allocation decision information S_{USCU} and downlink CQI information S_{DCQB} as input, generates Physical Uplink Control Channel (PUCCH) S_{UCCU} in which the downlink CQI information S_{DCQB} is multiplexed with a predetermined resource for a control signal indicated by the uplink RB allocation decision information S_{USCU}, and outputs it (Step S**17**).

The uplink RS signal generator **212** receives the uplink RB allocation decision information S_{USCU} as input, generates an uplink RS transmit signal S_{URSU} using a predetermined resource for RS in the uplink RB allocation decision information S_{USCU}, and outputs it (Step S**18**).

The uplink data signal generator **213** receives the uplink RB allocation decision information S_{USCU} as input, generates Physical Uplink Shared Channel (PUSCH) S_{UDCU} using a predetermined resource for a data signal in the uplink RB allocation decision information S_{USCU}, and outputs it (Step S**19**).

The multiplexer **214** receives the PUCCH S_{UCCU}, uplink RS transmit signal S_{URSU}, PUSCH S_{UDCU} and downlink control signal decision signal S_{DAKU} as input, and multiplexes these signals to generate a mobile station multiplexed signal S_{MUXU}; the transmitter **215** transmits the mobile station transmit signal S_{MUXU} to the base station **100** (Step S**20**).

While the explanation has been made in the preceding description with reference to a configuration in which, after allocating resource blocks with a determined allocation resolution, a check is made as to whether information representing the allocated resource blocks can be transmitted with a smaller number of bits, another configuration may be contemplated in which, after simply allocating resource blocks, a check is made as to whether information representing the allocated resource blocks can be transmitted with a smaller number of bits.

According to the present embodiment, since a sequence of allocated resource blocks is checked to confirm whether transmission may be made with a smaller number of bits than that for determining information representing the allocated resource blocks, UL Scheduling Grant can be reliably transmitted with a smaller number of bits.

While a mode in which uplink resource blocks are allocated has been described in the embodiments above, the mode may be one such that downlink resource blocks are allocated. In such a case, the number of frequency blocks or maximum number of frequency blocks may be information varying in accordance with a communication environment, such as, for example, the cell size, system bandwidth, coverage of a base station, channel quality information measured by a downlink reference signal, bandwidth of downlink data signals, and number of levels in multi-level modulation for downlink data signals, or code rate. Moreover, since the aforementioned cell size is determined by information affecting the communication environment such as the location of a base station, distance between base stations, and interference power, the number of frequency blocks may be selected using such information.

Furthermore, a mode in which the mode of allocating uplink resource blocks is combined with the mode of allocating downlink resource blocks may be contemplated.

In addition, while it is possible to configure the mobile station and base station in the present invention described above by hardware, they may be implemented by a computer program as obvious from the preceding description.

A processor operated by programs stored in a program memory implements functions and operations similar to those in the embodiments described above. It should be noted that part of functions of the embodiments described above may be implemented by a computer program.

While the present invention has been described with reference to several embodiments, it is not limited thereto. Various modifications that those skilled in the art can appreciate may be made to the configuration or details of the present invention within a scope of the present invention.

The present application claims priority based on Japanese Patent Application No. 2008-161752 filed on Jun. 20, 2008, disclosure of which is incorporated herein in its entirety.

The invention claimed is:

1. A resource allocating method comprising:

transmitting, by a base station, a downlink control signal comprising type information, wherein the type information indicates one of:

a first uplink resource allocation type for allocating one frequency block, and

a second uplink resource allocation type for allocating a plurality of frequency blocks;

if the type information indicates the first uplink resource allocation type:

transmitting, by the base station, first uplink resource allocation information indicating the one frequency block, and

receiving, by the base station, first uplink data using the one frequency block; and

if the type information indicates the second uplink resource allocation type:

transmitting, by the base station, second uplink resource allocation information indicating the plurality of frequency blocks, wherein an allocation unit of the first uplink resource allocation information is smaller than an allocation unit of the second uplink resource allocation information, and

receiving, by the base station, second uplink data using the plurality of frequency blocks;

wherein, at least one resource block, which is not included in the plurality of frequency blocks of the second uplink resource allocation information, is located between each two of the plurality of frequency blocks of the second uplink resource allocation information.

2. A resource allocating method comprising:

receiving, by a mobile station, a downlink control signal comprising type information indicating one of:

a first uplink resource allocation type for allocating one frequency block, and

a second uplink resource allocation type for allocating a plurality of frequency blocks;

if the type information indicates the first uplink resource allocation type:

receiving, by the mobile station, first uplink resource allocation information indicating the one frequency block, and

transmitting, by the mobile station, first uplink data using the one frequency block; and

if the type information indicates the second uplink resource allocation type:

receiving, by the mobile station, second uplink resource allocation information indicating the plurality of frequency blocks, wherein an allocation unit of the first uplink resource allocation information is smaller than an allocation unit of the second uplink resource allocation information, and

transmitting, by the mobile station, second uplink data using the plurality of frequency blocks;

wherein, at least one resource block, which is not included in the plurality of frequency blocks of the second uplink resource allocation information, is located between each two of the plurality of frequency blocks of the second uplink resource allocation information.

3. A base station comprising:

a transmitter configured to transmit a downlink control signal comprising type information indicating one of:

a first uplink resource allocation type for allocating one frequency block, and

a second uplink resource allocation type for allocating a plurality of frequency blocks;

wherein the transmitter is further configured to transmit:

first uplink resource allocation information indicating the one frequency block, if the type information indicates the first uplink resource allocation type, and

second uplink resource allocation information indicating the plurality of frequency blocks if the type information indicates the second uplink resource allocation type, wherein an allocation unit of the first uplink resource allocation information is smaller than an allocation unit of the second uplink resource allocation information; and

a receiver configured to receive:

first uplink data using the one frequency block if the type information indicates the first uplink resource allocation type, and

second uplink data using the plurality of frequency blocks if the type information indicates the second uplink resource allocation type;

wherein, at least one resource block, which is not included in the plurality of frequency blocks of the second uplink resource allocation information, is located between each two of the plurality of frequency blocks of the second uplink resource allocation information.

4. A mobile station comprising:

a receiver configured to receive a downlink control signal comprising type information indicating one of:

a first uplink resource allocation type for allocating one frequency block, and

a second uplink resource allocation type for allocating a plurality of frequency blocks;

wherein the receiver is further configured to receive:

first uplink resource allocation information indicating the one frequency block if the type information indicates the first uplink resource allocation type, and

second uplink resource allocation information indicating the plurality of frequency blocks if the type information indicates the second uplink resource allocation type, wherein an allocation unit of the first uplink resource allocation information is smaller than an allocation unit of the second uplink resource allocation information; and

a transmitter configured to transmit:

first uplink data using the one frequency block if the type information indicates the first uplink resource allocation type, and

second uplink data using the plurality of frequency blocks if the type information indicates the second uplink resource allocation type;

wherein, at least one resource block, which is not included in the plurality of frequency blocks of the second uplink resource allocation information, is located between each two of the plurality of frequency blocks of the second uplink resource allocation information.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 9,350,485 B2
APPLICATION NO. : 13/000301
DATED : May 24, 2016
INVENTOR(S) : Kenji Koyanagi et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Specification

Column 8, Line 22: Delete "109" and insert --107--

Column 10, Line 42: Delete "S_{DSCB}" and insert --S_{DDCB}--

Column 10, Line 42: Delete "S_{DSCB}," and insert --S_{DCCB},--

Column 15, Line 38: Delete "S_{USCU}" and insert --S_{UDCU}--

Column 21, Line 11: Delete "S_{UCQB}" and insert --S_{DCQB}--

Column 22, Line 11: Delete "S_{RXB}," and insert --S_{RXB}--

Signed and Sealed this
Fourth Day of October, 2016

Michelle K. Lee

Michelle K. Lee
Director of the United States Patent and Trademark Office